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S. HRG. 103–487

WORLD FOOD PRODUCTION

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World Food Production. S. Hrg. 103-... RING

BEFORE A

SUBCOMMITTEE OF THE

COMMITTEE ON APPROPRIATIONS

UNITED STATES SENATE

ONE HUNDRED THIRD CONGRESS

SECOND SESSION

SPECIAL HEARING

Printed for the use of the Committee on Appropriations

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WORLD FOOD PRODUCTION

WEDNESDAY, FEBRUARY 23, 1994

U.S. SENATE,
SUBCOMMITTEE ON AGRICULTURE, RURAL
DEVELOPMENT, AND RELATED AGENCIES,
COMMITTEE ON APPROPRIATIONS,
Washington, DC.

The subcommittee met at 2 p.m., in room SD–138, Dirksen Senate Office Building, Hon. Dale Bumpers (chairman) presiding.

Present: Senators Bumpers and Cochran.

NONDEPARTMENTAL WITNESSES

WORLDWATCH INSTITUTE

STATEMENT OF LESTER R. BROWN, PRESIDENT

OPENING REMARKS OF SENATOR BUMPERS

Senator BUMPERS. Today, we are holding the first hearing of this year for the Appropriations Subcommittee on Agriculture. And this is a special hearing that differs from our normal hearings, which generally deal with the budget. We will discuss world food production, which is a topic that does not get nearly enough attention by the media or the politicians, in my view. And you can see from the attendance this afternoon how important this subject is to the media.

Now, if this hearing were on Whitewater, there would be 40 cameras here. And I can tell you Whitewater is not even a blip compared to the subject matter this afternoon.

Many people look at crop production on an annual basis, and current regional famines. But I want to look at a bigger global picture, and I want to look a little further into the future than the next year or two. We have several distinguished witnesses before us.

First, Lester Brown, president of Worldwatch Institute. Mr. Brown began as a farmer; spent some time in rural India; worked for USDA's Foreign Agricultural Service; and was an advisor to Agriculture Secretary Orville Freeman. Mr. Brown founded Worldwatch Institute, a private nonprofit research institute devoted to the analysis of global environmental issues. And in that capacity, he launched the "State of the World" annual reports, the bimonthly magazine Worldwatch, and a new annual, "Vital Signs: The Trends That Are Shaping Our Future."

In addition, Mr. Brown has written a dozen books, including "Man, Land and Food," "World Without Borders," "By Bread Alone," and "Building a Sustainable Society," and he coauthored

"Saving the Planet: How to Shape an Environmentally Sustainable Global Economy."

Mr. Brown, recipient of a $250,000 MacArthur Foundation genius award, and winner of the United Nations' 1989 environment prize, has been described by the Washington Post as one of the world's most influential thinkers.

We have written statements from each of the witnesses. They will be made a part of the record in full. I would hope that some of you, or all of you, could summarize your statements so that we have time for ample discussion.

But, first, we will hear from Mr. Brown.

Mr. Brown, thank you very much for coming today. We look forward to hearing your testimony.

STATEMENT OF LESTER R. BROWN

Mr. BROWN. Thank you, Mr. Chairman.

I would like to divide this up into three sections in looking at world food security, looking at the three basic systems that we depend on for food. One is oceanic fisheries. The other is the world's rangelands. And the third, of course, is croplands, the most basic of all.

Over the last four decades, the world fish catch has increased 4½ times. The per capita fish catch has gone from 9 kilograms per person in 1950, to 19 kilograms today. That is to say, each of us in the world today is consuming twice as much seafood as we did at midcentury. So, there has been an enormous increase in protein intake on that front.

That is the good news. The bad news is that when the fish catch hit 100 million tons in 1989, that was the level that some marine biologists, some 20 years ago, said would likely be the upper ceiling on what the oceans could sustain. Since then, the catch has dropped down to 97 million tons, 97, back up to 98. But the evidence indicates that 100 million tons probably is going to be a difficult level to break through in terms of a sustainable catch from oceanic fisheries.

The marine biologists at FAO, who monitor fisheries fairly carefully, report that of the 17 major fishing areas in the world, all are now being fished at or beyond capacity, and 9 are in a state of decline.

Senator BUMPERS. How many major fishing areas?

Mr. BROWN. Seventeen. All 17 are now being fished at or beyond capacity; 9 are in a state of decline.

We are seeing some of that here on our own east coast. As you know, the cod and haddock fisheries off the coast of Newfoundland and Labrador were closed I think 1½ years ago, and we are now imposing fairly serious limits on cod and haddock and flounder off the New England coast, George's Bank and that area because the stocks are so severely depleted.

This obviously has economic consequences, with 30,000 Canadian fishermen unemployed, for example, and the $400 million rescue program by the Canadian Government.

As we look ahead, the inevitable prospect is for the seafood catch per person to decline as far we can see into the future, as far as population grows. If we use the U.N. projections of population,

then, within the next four decades, the fish catch per person will drop down to almost the same level it was in 1950. That is to say, the next four decades will be essentially a mirror image of the last four decades: the last four decades going up; the next four decades going down.

What this will do for seafood prices is a matter of concern, I think. If you have been to a seafood shop to get fresh seafood of late, you have to be impressed with the prices. It is hard to find anything for less than $4 a pound. It may be $7, $9, $11, or even $14 a pound. The index of seafood prices is going up twice as fast as that for beef or pork or poultry.

So, I think on the seafood front we are faced with declining availability and, in all likelihood, continuing rises in prices.

With rangelands, which is the other natural system that supplies a great deal of our animal protein, we are seeing a somewhat similar situation. Indeed, the language that is used by marine biologists to discuss the condition of fisheries today can also be applied to most of the world's rangelands. That is to say, they are being grazed at or beyond capacity in large areas of the world today.

We do not have the precise measurement of livestock products that come from rangeland because there is a fair amount that is grain-fed and there is no way of separating this for the world. We do know that the production of beef and mutton that come largely from rangeland, that the production has leveled off in the last few years, and probably will not increase very much except insofar as we do it in the feedlot. But with either fish or beef or mutton, if we want more now, we basically have to feed to get it. We cannot get it from the natural system.

The trend for the fish catch is graphed on page 182. I think you should have a handout at the last chapter of "State of the World 1994."

Senator BUMPERS. I have it, Mr. Brown.

Mr. BROWN. Page 182 is a graph of the per capita fish catch from 1950 up until 1992, with projections to 2030. I might say that I am going to be using two time periods in this presentation, looking back at the last four decades, and looking ahead at the next four decades. I would point out that with population growth over the last four decades, we added 2.8 billion people, or 70 million a year. Over the next four decades, the U.N. median projection show an addition of 3.6 billion, or 90 million per year.

We then come to croplands and the potential for expanding production of, basically, grain, which is what most of the world's croplands are used for. Grain also dominates our diets. One-half of our direct calories consumed come from grain. And a good part of the remainder come from grain in the form of livestock products.

As we look ahead, most of the recent projections do not show a lot of growth in the cropland area. In most areas of the world, the good cropland is already under the plow. There are a few possible exceptions, particularly if we get some rises in world prices, possibly in Argentina, possibly in Brazil. But, in most of the world, there is just not a lot of potential for expanding the area.

That leaves us, then, focusing on land productivity and the potential for raising that over the next four decades. And I would draw your attention here to the graphs on page 183. If you look at

the chart on the bottom on the left, U.S. corn yield per hectare, what this shows is that from the Civil War until World War II, there was no particular change in corn yield per hectare in this country. If anything, it was going down slightly during that period. And then, yields began to increase dramatically, and actually increased fourfold since 1940.

Over the last several years, however, the growth has clearly been slowing. And we may see something of a leveling off there.

The other major grain, wheat, we can see the yield trends for France, which is the largest wheat producer in Europe. That trend for France could also be essentially the trend for the United Kingdom or for Germany—steady growth up until recent years, and then a clear slowdown in the rise.

The two countries at the bottom, China and the United States, are the world's largest wheat producers. We see China, which is on the bottom until about 1980 or so, and then the lines cross. The agricultural reforms in 1978 can be seen very clearly here as China almost doubled its wheat yields there in a matter of 8 years or so.

Senator BUMPERS. Mr. Brown, in connection with what you just said, I want to be sure I understand it. You are telling me that since roughly 1983, China's wheat yields per hectare has overtaken the United States?

Mr. BROWN. Yes.

Senator BUMPERS. Where those lines cross?

Mr. BROWN. That is right.

Senator BUMPERS. Go ahead.

Mr. BROWN. And that comes as no surprise, because they have a significant percentage of irrigated wheat area. And with the agricultural reforms and the availability of fertilizer, that was to be expected.

Senator BUMPERS. Why is France's so much greater than ours?

Mr. BROWN. Rainfall. All France's wheatland is well watered. Most of ours is dryland wheat, with rather low rainfall.

Senator BUMPERS. Go ahead. I do not want to interrupt you until you are finished.

Mr. BROWN. All right.

So, what we are seeing is a slowdown in the rise in yields. Both China's wheat yields over the last 8 or 9 years have increased very little compared with the preceding decade, and, similarly, U.S. wheat yields appear to be leveling off, as well.

The chart at the bottom shows rice yields: Japan at the top with the highest yields in the world. And, again, you can see there that rice yields have not increased over the last decade. The drop in the last year or two is really a function of weather and not to be regarded too seriously.

The important point here is that in Japan the support price or rice is six times the world market level. If you want to make money in Japan, the way to do it is to raise rice yields. But Japan's farmers are simply not able to. They are doing everything they know how to do to raise rice yields, using all the latest technologies, and cannot take it any higher.

China is now getting close to Japan in its rice yields, and also, as you can see there, in the last several years, the increase in rice yields has been rather minimal.

Senator BUMPERS. You do not have the United States in that chart.

Mr. BROWN. No.

Senator BUMPERS. Coming from the biggest rice producing State in the Nation, how come?

Mr. BROWN. I could actually put Arkansas on here if you would like, sir. [Laughter.]

Senator BUMPERS. Well, please do. I want to know where we rank with China and Japan and India.

Mr. BROWN. Almost exactly the same as Japan. The United States has——

Senator BUMPERS. A big producer per hectare?

Mr. BROWN. Yes; our rice yields are quite high.

And, again, that is because all of our rice is irrigated. The reason India is so far down here—there are two reasons—one is that the percentage of irrigated riceland in India is about 43 percent, compared with 94 and 99 percent in China and Japan. And with only 43 percent of the riceland irrigated, it is difficult to use fertilizer on the rest of the land because they cannot control the water. If you cannot control the water, it is hard to use fertilizer effectively.

The other reason that rice yields in India are lower than in China and Japan is because it is closer to the equator. And there is a yield differential that increases with latitude, because, as you move north, the day length is longer in summertime, during the key growing season. India, being close to the equator, does not have the advantage that China or Japan or the United States have.

That also is a real advantage for Western Europe with wheat, in addition to having usually an abundance of rainfall, they are at a latitude where they have very long days in the summertime that contributes to their higher yields.

In looking at the trend in world grain production, indeed, in yields in a lot of these individual countries, if we look at the period from 1950 through 1993, 1984 looks like some sort of a geological fault line in these trends. There is a real change there. And the question is, why this dramatic slowdown after 1984?

And I have concluded that 1984 was the point at which we began to experience some rather dramatic declines in response to the use of additional fertilizer. If you will turn to page 185, this is a chart that measures very roughly the response of grain production to fertilizer use. And if you look at the right-hand column, what that says is that from 1950 to 1984, each additional ton of fertilizer increased grain output by 9 tons. And this says, from 1984 until 1989, that response dropped to 2 tons. That is, each ton of fertilizer got a bit less than 2 tons of additional grain.

Now, economically, that is not a winning combination for farmers. And what had happened, apparently, is that from midcentury on, farmers almost everywhere had gotten in the habit of using more and more fertilizer and varieties that were always more responsive to fertilizer. And when they reached the point where the fertilizer responsiveness of varieties was no longer increasing, they did not realize it, and they kept putting on more fertilizer, expecting to get more output.

By 1989, they realized that this was not working any more. Actually, farmers in this country began leveling off their fertilizer use

around 1980. But, then, world fertilizer use actually dropped. If you look at the middle column, you will see it. It reached 146 million tons in 1989. That is the historical peak. It has now dropped to about 130 million tons.

Now, there are two things involved here—one is the actual leveling off of fertilizer use because grain yields do not respond so much any more. And the other is that a number of countries reduced subsidies over the last several years—the former Soviet Union being the most dramatic one, where they moved to world market prices. And, for farmers, that meant fertilizer prices at least twice as high as they had been before the reforms; and other countries, India, China, also cutting back on fertilizer subsidies.

So, there are two things at work here—one is the leveling off, and that is because of the agronomic response; the other is the actual decline. And that is largely because of the removal of subsidies.

Now, one of the interesting questions is, if the fertilizer engine that has been driving the dramatic growth in world food output over the last four decades—or at least from 1950 to 1984—when grain output increased by at least 2.5 times, unprecedented growth, nothing like it historically—the question is, if that engine that was driving the growth is no longer driving it, or we cannot expect it to drive it in the same way in the future, then how can we get the increases in output to feed the 90 million people we will be adding between now and 2030? That, I think, is a central question that is going to bear on food security very directly, and probably will begin to show up in the next few years.

One of the things we did here—and, incidentally, I might make one other general point, and that is that the backlog of agricultural technology appears to be diminishing rather substantially. Over the last four decades, we have been using technologies that were already available before midcentury.

For example, von Leipig, the German chemist, demonstrated in 1847 that all the nutrients that plants took from the soil we could put back in mineral form. So, he established the foundation for the chemical fertilizer industry.

Mendel did his trailblazing work in the 1860's, establishing the principles of plant genetics. So, that was already there.

Hybrid corn was on the market in the 1930's.

The dwarf genes in both wheat and rice that were at the heart of the green revolution in Asia over the last 25 years were already isolated and being used by the Japanese a century ago.

Irrigation, of course, has been around for a long, long time.

So, all the technologies that have led to the quantum jumps since midcentury are ones that were available before the period began. And what we were doing during that period is creating the economic policies to make their use profitable, and refining them for local use throughout the entire world. So, that was a unique period.

As we look ahead, it is hard to see any technologies available now or in the immediate prospect that will lead to quantum jumps in output comparable to the hybridization of corn or the use of chemical fertilizer, et cetera.

One of the things we did in looking at the future in food security was to ask ourselves, given this new situation, what I consider to

be a new era in the world food economy, what are the prospects for rapidly expanding production over the next four decades?

And what we have done is ask ourselves, what if farmers expand production as rapidly from now until 2030 as they have over the last 8 years, from say 1984 until 1992?

Prior to then, 1950 to 1984, world grain output increased by 30 million tons per year on average—really, a very robust expansion. Since 1984, it has been increasing by about 12 million tons per years, from 1984 to 1992. If you use 1993, which was a down year, it would be less than that. But using 12 million tons a year, and projecting that to 2030, you see the world grain harvest going from 1.7 billion tons to 2.2 billion tons. And we see the per capita grain production, graphed on page 186, and which increased about 40 percent from 1950 to 1984, declining as we move toward 2030.

Now, this assumes that there will be no dramatic new technology like hybrid corn or the discovery of fertilizer or what have you. If we do come up with something really dramatic, that has worldwide application, then we can go faster. But, if we cannot, then we are faced with a situation somewhat similar to that for oceanic fisheries—that is, a gradual decline in grain production per person.

To put this in perspective, in 1984, at the peak, grain production per person in the world was 346 kilograms. That is midway between China and Italy—China at 300 kilograms, Italy at 400 kilograms—the United States is 800. So, the world, in 1984, was midway between China and Italy. If it continues along this trend, it will drop to 248 kilograms by 2030, which puts it midway between China and India today.

So, the real challenge to food security is to figure out some way of preventing this trend from declining, and getting it to go back up, if possible. And I think that is going to take a lot of work on both the agricultural and the population side of the equation.

And I think one of the differences between the next four decades and the last four decades is, over the last four decades, the world's fishermen and farmers could pretty much keep up with population growth. Treating it as a variable, they were able to keep up with it and, indeed, move much faster than population growth throughout most of this period. But over the next four decades, I think it is going to be very difficult for them to do that. And, indeed, I think virtually impossible for fishermen, and difficult for farmers.

What I think we are now faced with is a need to do some serious thinking about the carrying capacity of the land in various countries around the world, and to look at the projected growth in population, and use the information we now have. I mean, we know what to expect in terms of the seafood catch. We know we cannot expect a great deal more from rangelands. We know now where yields are leveling off in the highest yield countries. I think it is going to be difficult for any country to push its yields much above those in Japan today, for example.

So, we are beginning to get some reference points that we can use for some calculations. And I think the time has come to do those. And I think, as a country, we probably ought to be taking some leadership on this.

One of the reasons I think this is important is evident, I think, in the table on page 188. What we have here is a table of roughly

the 20 or so most populous countries in the world, divided into the industrial or slow-growing countries, and the rapid-growing or developing countries. And the key columns are the two on the right, which compare population growth over the last four decades with the projected growth over the next four decades.

For the industrial countries, we are basically at population stability, except for the United States. We are projected to add 95 million people, increasing our population by, I think, some 38 percent over the next four decades. But, other than that, the other industrial countries are fairly stable.

The developing countries, however, it is a very different situation. If you look at Nigeria, which is second in the rapidly growing category, you see that over the last four decades they added 55 million people. They are projected to add 191 million.

Ethiopia and Eritrea added 30 million over the last four decades; projected to add 106 million.

Iran, 41 million versus 126, and you can go down the line. Even China, which has been pushing about as hard as a government can possibly push to slow its population growth, is projected to add 490 million people over the next four decades.

So, it seems to me we have reached the point where we need to begin doing some country-by-country analysis and see what the potential is to expand the seafood catch, rangeland production of livestock products, and crop production—importantly, grain, and put that beside the projected growth in population and any assumed increases in per capita consumption that we think are reasonable for, particularly, the developing countries.

If we do that, and we have begun to start to work through that exercise for a number of these countries, what you see is a lot of countries moving into situations with fairly substantial deficits, and not very many countries moving ahead with large surpluses. So, we may be in a situation where we have to recognize that establishing an adequate and humane balance between food and people over the next four decades may require a much greater assist from the family planners than has been the case in the past.

And here, I am pleased to say that the United States has, over the past year, restored funding for the United Nations Population Fund and for the International Planned Parenthood Federation, two major international family planning agencies.

Under Secretary Tim Wirth recently announced that the United States has now adopted as a goal filling the family planning gap by the end of this decade. There are an estimated 100 million or so women in the world who want to limit the size of the families but are not able to do so because they lack access to family planning services. He has said that the United States goal—and I think Japan is lining up behind this goal now—is to make sure that by the end of this decade no woman in the world who wants access to family planning services will be denied them.

I think that is a terribly important step in the right direction, and one of the obvious kinds of things we need to do.

On the food side, it seems to me we need to be concentrating on everything from reducing soil erosion, protecting the land and water base, to investing more in research, more in water efficiency research, particularly because the higher we get with yields, the

more investment it takes to stay there. There is such a thing as maintenance research. If we were to stop research altogether, yields would gradually wind down almost everywhere in the world.

So, it takes a fair amount of research just to stay where we are now. And if we want to keep moving up, it is going to take a lot more. And, as you were indicating in your introductory comments, there just has not been a lot of attention paid to these issues here in Washington in the last few years.

I think the time has come to do that, partly because we are beginning to see potential economic consequences. And I think these are most clear with oceanic fisheries, with the unemployment, with the rapidly rising seafood prices.

We may now be seeing some of this with rice. As you know, the price of rice has doubled since the end of August, of obvious benefit to your rice growers in Arkansas. But for low-income countries in Asia that import rice, this is a difficult one to handle.

The real challenge of 1994 is whether the rice growers in the world can increase yields enough to get ahead of consumption. Because, for the last 3 years, world rice consumption has exceeded production. And if they can get ahead, then rice prices can ease back down a bit. If they cannot catch up, then high rice prices could join high seafood prices as part of the economic landscape.

Thank you.

PREPARED STATEMENT

Senator BUMPERS. Thank you, Mr. Brown, for your testimony. We have your complete statement and it will be made part of the record.

[The statement follows:]

STATEMENT OF LESTER R. BROWN

FACING FOOD INSECURITY

As the nineties unfold, the world is facing a day of reckoning. Many knew that this time would eventually come, that at some point the cumulative effects of environmental degradation and the limits of the earth's natural systems would start to restrict economic expansion. But no one knew exactly when or how these effects would show up. Now we can see that they are slowing growth in food production—the most basic of economic activities and the one on which all others depend.

After nearly four decades of unprecedented expansion in both land-based and oceanic food supplies, the world is experiencing a massive loss of momentum. Between 1950 and 1984, world grain production expanded 2.6-fold, outstripping population growth by a wide margin and raising the grain harvested per person by 40 percent. Growth in the world fish catch was even more spectacular—a 4.6-fold increase between 1950 and 1989, which doubled the seafood catch per person. Together, these developments reduced hunger and malnutrition throughout the world, offering hope that they would one day be eliminated.[1]

But in recent years these trends in food output per person have been reversed with unanticipated abruptness. By 1993, the fish catch per person had declined some 7 percent from its historical high in 1989. And after 1984, the growth in grain production slowed abruptly, falling behind that of population. From 1984 until 1993, grain output per person fell 11 percent. Historians may well see 1984 as a watershed year, one marking the transition from an era of rapid growth in food production to one of much slower growth.[2]

In a world of growing food insecurity, grain output per person becomes a proxy for progress, a basic indicator measuring success in accelerating food output and slowing population growth. It readily measures the effect on demand of both population growth and rising affluence, as the latter boosts the amount of grain used to produce livestock products.

Human demands are approaching the limits of oceanic fisheries to supply fish, of rangelands to support livestock, and, in many countries, of the hydrological cycle to produce fresh water. Even as these constraints become more visible, the backlog of unused agricultural technology is shrinking in industrial and developing countries alike, slowing the rise in cropland productivity. At the same time, soil erosion, air pollution, soil compaction, aquifer depletion, the loss

of soil organic matter, and the waterlogging and salting of irrigated land are all slowing the rise in food output. At present, there is nothing in sight to reverse the worldwide decline in grain output per person.

The bottom line is that the world's farmers can no longer be counted on to feed the projected additions to our numbers. Achieving a humane balance between food and people now depends more on family planners than on farmers. Against this backdrop, the timing of the International Conference on Population and Development in September 1994 in Cairo could not be better.

Between 1950 and 1990, the world added 2.8 billion people, an average of 70 million a year. But between 1990 and 2030, the world is projected to add 3.6 billion, an annual average of 90 million. Such growth in a finite environment raises questions about the earth's carrying capacity. (See Chapter 1.) Will the earth's natural support systems sustain such growth indefinitely? How many people can the earth support at a given level of consumption?[3]

As food production per person falls, the nature of famine itself is changing. Traditionally it was geographically defined, concentrated where there were crop failures. With today's worldwide food distribution system, malnutrition so severe that it is life-threatening is found mainly among the Third World's landless rural laborers and urban poor. Although the hungry are more dispersed and less visible, they are no less numerous. The latest U.N. assessment puts the number of malnourished at close to 1 billion, nearly one in five persons.[4]

The ideological conflict that dominated the four decades from 1950 to 1990 is being replaced by the conflict between our steadily growing demand for food and the earth's physical capacity to satisfy those demands. In a world of spreading hunger, desperate people may cross national borders in unprecedented numbers in their search for food. The deteriorating balance between food and people in one way or another will increasingly preoccupy national political leaders, reorder national priorities, and dominate international affairs.[5]

This chapter builds on the assessment in Chapter 1 of how environmental degradation is affecting the food economy, adding to it an analysis of cropland productivity trends, to provide a base for looking ahead at the food-population balance. Looking at trends in the use of land, water, and fertilizer and at cropland productivity during the last 40 years provides some insights into what to expect during the next 40. It would be tempting to use a shorter time frame, but in dealing with basic policy questions—the need to stabilize both population and climate, and to develop and disseminate new farming technologies—such an approach is of limited value.

Looking Back, Looking Ahead

During the last four decades, economic policies dominated the evolution of the global economy. During the next four, environmental limits interacting with population growth will have far more influence. Fully 96 percent of the projected addition of 3.6 billion people between 1990 and 2030 will occur in the Third World. In countries where demands already exceed local carrying capacity, the resulting deforestation, overgrazing, soil erosion, and aquifer depletion will accelerate and spread—creating a highly unstable relationship between people and their natural support systems. The changing relationship is clearly visible at the global level,

where population growth is outrunning production of oceanic fisheries, rangelands, and croplands.[6]

Between 1950 and 1989, the world fish harvest—a major source of animal protein—increased from 22 million to 100 million tons, lifting the supply per person from an average of 9 kilograms to 19. (See Figure 10–1.) This phenomenal growth may have ended, however. Marine biologists from the U.N. Food and Agriculture Organization estimate that oceanic fisheries may not be able to sustain a harvest higher than that of recent years. (See Chapter 3.) If they are right, then the rise in the seafood catch per person of the past four decades has come to an end, to be replaced by a steady decline for as long as population grows.[7]

The world's rangelands, another major source of animal protein, are also under growing pressure. Between 1950 and 1990, world output of beef and mutton increased 2.6-fold, raising the per capita supply some 26 percent. With extensive overgrazing on every continent, however, rangelands—like oceanic fisheries—may be at their maximum carrying capacity. If so, rangeland production of beef and mutton may not increase much, if at all, in the future. Here, too, availability per person will decline indefinitely as population grows.[8]

If the supply of fish, beef, and mutton is to expand in the future, it will have to come from feeding fish in ponds or livestock in feedlots. And this in turn will depend on producing more grain. Yet production of grain—the mainstay of the human diet, accounting for half of human caloric intake consumed directly and part of the remainder consumed indirectly as livestock products—has also slowed. Between 1950 and 1984, the world grain harvest grew at a record 3 percent a year, boosting per capita grain availability by some 40 percent. But from 1984 to 1993, annual growth slowed to less than 1 percent, dropping per capita availability by 11 percent.[9]

These slowdowns in major food-producing sectors of the global economy affect overall economic trends. Growth in the world economy reached its historical high of 5.2 percent a year during the sixties; it slowed some in the seventies and still further in the eighties, dropping to 2.9 percent. (See Table 10–1.) Despite this, the per capita output of goods and services rose as overall economic growth stayed ahead of population. Now that, too, may be changing. From 1990 to 1993, the world economy expanded

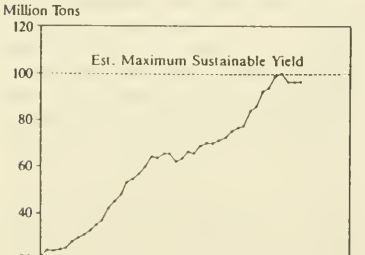


Figure 10-1. World Fish Harvest, 1950-92

Table 10–1. World Economic Growth by Decade, Total and Per Person, 1950–93

Decade	Annual Growth	Annual Growth Per Person
	(percent)	
1950–60	4.9	3.1
1960–70	5.2	3.2
1970–80	3.4	1.6
1980–90	2.9	1.1
1990–93 (prel.)	0.9	−0.8

SOURCE: Worldwatch Institute, based on sources documented in endnote 10.

annually at just 0.9 percent, leading to a per capita decline of 0.8 percent a year. Thus three years into the new decade, income per person is 2 percent lower than it was when the nineties began. Even using an economic accounting system that overstates progress because it omits the depletion of natural capital, living standards are falling.[10]

These economic trends help explain why grain production per person could be falling so much without any rise in grain prices. The worldwide decline in income during the early nineties was preceded by a drop in incomes between 1980 and 1990 in some 42 countries with some 850 million people—including many of the world's poorest, those for whom the link between income and food consumption is strongest. In addition, the collapse in purchasing power in the former Soviet Union following economic reforms has lowered grain use, sharply reducing imports.[11]

The experience of recent decades with overfishing and overgrazing gives a sense of the limits to the carrying capacity of fisheries and rangelands.

Although the first three years of the nineties were recession-ridden and thus should not be taken to represent the new decade, the world economy is not growing as easily as it once did. Economic mismanagement in key industrial countries (particularly the United States, Germany, and Japan) and the disruption associated with economic reform in Eastern Europe are impeding economic growth. But global economic expansion is also now constrained by no growth in the fishing industry, no growth in the production of beef, mutton, and other livestock products from the world's rangelands, and a world grain harvest expanding at less than 1 percent a year.[12]

While farming, ranching, and fishing are not as dominant in the modern industrial world as they once were, a slowdown in these basic sectors affects the entire economy. With constraints emerging in primary food-producing sectors—which the Third World depends on heavily—the world may be moving into an era of slower economic growth overall. (See Table 10–2.)

The Changing Food Outlook

New information on the sustainable-yield potential of the three food production systems—fisheries, rangelands, and croplands—makes it easier to project future output. The experience of recent decades with overfishing and overgrazing gives a sense of the limits to the carrying capacity of fisheries and rangelands. And with grain yield per hectare in countries now growing much more slowly and the cropland area essentially fixed, trends can now be predicted with some confidence, assuming no dramatic new breakthroughs.

If oceanic and inland fisheries cannot sustain a catch any greater than the record catch of 1989, and if—for purposes of calculation—it is assumed that additional grain will not be available to sustain future growth in aquaculture, seafood supply per person will decline steadily from now until 2030, reversing the trend of the last 40 years. (See Figure 10–2.) By then, the per capita seafood supply, which peaked at 19 kilograms in 1989, will be back down to 11 kilograms—only slightly above the level in 1950.[13]

Table 10–2. Comparison of Key Global Indicators in the Economic Era and the Environmental Era

Indicator	The Economic Era: 1950–90	The Environmental Era: 1990–2030
World Population	More than doubled from 2.5 to 5.3 billion, adding 2.8 billion or 70 million per year and slowing progress.	Projected to increase from 5.3 to 8.9 billion, adding 3.6 billion or 90 million per year. For much of humanity, this may reverse progress.
Grain Production	Nearly tripled from 631 million tons to 1,780 million tons, or 29 million tons per year.	Expanding by 12 million tons per year (rate of last eight years) may be best that can be expected.
Beef and Mutton Production	Increased 2.6 times, from 24 to 62 million tons.	Little growth expected.
Fish Catch	From 22 to 100 million tons; per capita up from 9 to 19 kilograms.	No growth expected; per capita dropping from 19 kilograms to 11 kilograms.
Economic Growth	Economy expanded 4.9-fold from nearly $4 trillion to $19 trillion, an annual gain of 4.2 percent. Growth is focus of national economic policymaking.	Averaging even half the 1950–90 rate may be difficult. Focus will shift from growth to sustainability and distribution.
Growth in Grain Demand	Two thirds from population growth; one third from rising incomes.	Nearly all expansion will be needed to sustain population growth.
National Security	Largely ideological and military in nature; defined by the cold war.	Food and job security will dominate, often driving hungry and jobless people across national borders.

SOURCE: Worldwatch Institute.

Pressures on rangelands are similar to those on fisheries. With extensive overgrazing on every continent, the rangeland production of beef and mutton is unlikely to increase much if at all, leading to a steady decline in per capita supply. This affects most directly the pastoral economies of Africa, the Middle East, and Central Asia.[14]

Trying to maintain the historical growth in seafood supplies of 2 million tons a year would require an enormous increase in fish farming, which would use vast amounts of land, water, and feed. Even though fish are among the more efficient converters of grain into meat, needing only 2 pounds of feed per pound of weight gain, this would still require 4 million tons of additional grain per year. And if the million-ton-per-year

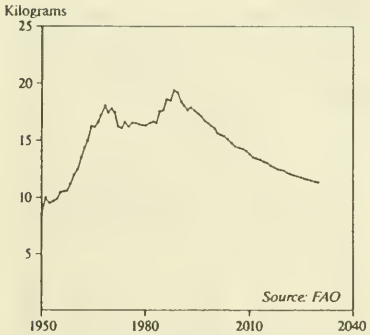


Figure 10-2. World Fish Harvest Per Person, 1950-92, With Projections to 2030

historical growth in beef and mutton output from rangelands is to rest on expanded feeding in feedlots, it will take an additional 7 million tons of grain each year, since steers in a feedlot typically require 7 pounds of grain for each pound of additional live weight gain. Thus maintaining the historical growth in both fish and beef supply would take 11 million tons of additional grain each year, an amount roughly equal to the annual increase in the world grain harvest in recent years.[15]

This raises the question of how rapidly grain production can be expanded, either by increasing planted area or by raising land productivity. Prospects for a major expansion of cropland that is economically profitable and environmentally sustainable are not good, since there is little fertile land waiting to be plowed. The last effort to expand the world's cultivated area, which followed a doubling of world grain prices in 1972, ended in a massive retrenchment.[16]

Between 1972 and 1981, farmers responded to sustained high prices by expanding the world grain area from 664 million to 735 million hectares, a gain of nearly 11 percent. Much of this expansion came in the Soviet Union and the United States on land that, unfortunately, was highly erodible and not capable of sustaining cultivation. After peaking at 123 million hectares in 1977, the Soviet Union's grain harvested area has declined each year, dropping to 99 million hectares in 1993 as fast-eroding land was either planted to soil-stabilizing forage crops, fallowed, or abandoned. In the United States, some 14 million hectares of the most erodible cropland were converted to grass or trees between 1985 and 1992 under the Conservation Reserve Program. In an emergency, some of this land could be farmed in rotation with forage crops or by using other appropriate conservation tillage practices.[17]

The United States is holding an additional 8 million hectares of grainland out of production under commodity supply management programs in 1993, and European countries may be holding out up to 3 million hectares. But even bringing all this land back into production would expand the world grain area by only 1.6 percent, not half enough to get it back to the historical high reached in 1981. The combination of the continuing abandonment of severely eroded land and the conversion of cropland to nonfarm uses means that net gains in the world's cropland area will not come easily.[18]

Since mid-century, countries that have not doubled, tripled, or even quadrupled the productivity of their cropland are the exceptions, not the rule. But with many of the world's farmers already using advanced yield-raising technologies, this rapid rise has lost momentum in recent years. A sense of the emerging constraints can be gleaned by analyzing historical trends in yield per hectare for each major cereal in the most agriculturally advanced countries.

Yields of corn, a cereal widely used for feed and food, are highest in the United States, which accounts for more than 40

percent of the world harvest. Data for U.S. corn yields from 1866 to 1993 divide into three distinct periods. (See Figure 10–3.) For seven decades, corn yields were essentially unchanged, averaging about 1.6 tons per hectare. The period from 1940 to 1985 saw an extraordinary growth of more than fourfold in the average yield, pushing it to 7.4 tons per hectare. In the eight years since then, the rise has slowed to a near standstill.[19]

A similar situation exists for wheat in the United Kingdom, which has the highest yield of any major wheat-producing country. From 1884 until 1940, yields were remarkably stable. From 1940 until 1984, they more than tripled. But in the following nine years, U.K. wheat yields fluctuated around 7.5 tons per hectare, showing little evidence of a continuing rapid rise.[20]

The rise in wheat yields in other parts of Europe with similar growing conditions is slowing as the output approaches the U.K. level. Among these are Germany and France, the latter a wheat exporter. The rise is also slowing in the United States and China, the world's two largest wheat exporters. (See Figure 10–4.) Since wheat in these two countries is grown in low-rainfall regions, the rise in yields is slowing at yield levels one third to one half those in Western Europe. In China, the big jump in wheat production came after the economic reforms in 1978, as yields climbed 81 percent from 1977 to 1984. During the nine years since then, they have risen only 16 percent.[21]

After increasing for nearly a century, the rise in rice yields in Japan came to a halt in 1984. Since then they have actually fallen slightly. (See Figure 10–5.) Yields in China, the world's largest rice

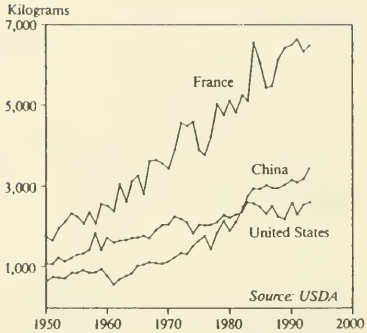


Figure 10-4. Wheat Yield Per Hectare, China, France, and United States, 1950–93

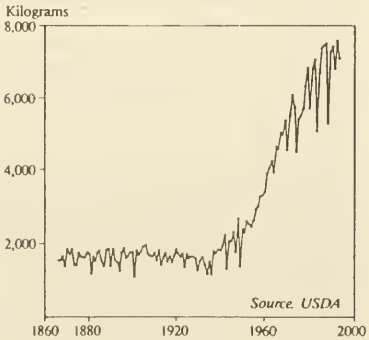


Figure 10-3. U.S. Corn Yield Per Hectare, 1866–1993

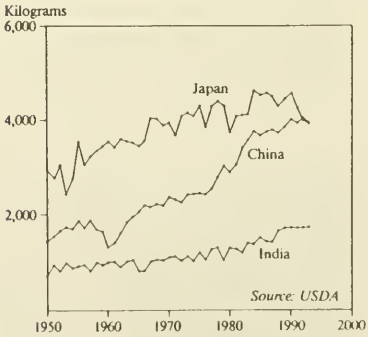


Figure 10-5. Rice Yield Per Hectare, China, India, and Japan, 1950–93

producer, now approach Japan's and have been stable since 1990. In India, the second ranking rice producer, the rise in yields has slowed at a much lower level, however. In Japan and China, 99 and 93 percent, respectively, of the rice is irrigated; in India, the figure is only 44 percent, making it far more difficult to achieve high yields. The yield rise has also slowed in other major rice-producing countries, including Indonesia, Pakistan, and the Philippines.[22]

The overall picture is equally sobering. From 1984 until 1993, world grain yields rose only 9 percent, or 1 percent year—less than half the rate of the preceding 34 years. For those who remember biology class experiments measuring the growth in a petri dish of an algae population with an unlimited food supply, this deceleration will not come as a surprise. With algae, it is the buildup of waste that eventually checks growth, bringing it to a halt. For grain with unlimited fertilizer supplies and abundant soil moisture, the plant's photosynthetic efficiency will ultimately check the rise in yield.[23]

Few countries that have doubled or tripled grain yields during the last several decades can expect to match that record during the next few.

Grain production per hectare is a natural process, one that relies on photosynthesis to convert solar energy into biochemical energy. Albeit modified by human intervention, it is—like all natural processes—subject to the biological limits of nature. These boundaries have been pushed back with great success during the last several decades, but that does not mean this can go on forever.

The engine driving the rise in grain yields from mid-century onward was the expanding use of fertilizer—specifically, the synergistic interactions of rising fertilizer use with expanding irrigation and the spread of grain varieties that were responsive to ever heavier applications of fertilizer. This formula was phenomenally successful from 1950 to 1984, when fertilizer use climbed from 14 million to 126 million tons. Moving to a new high nearly every year, it was one of the most predictable trends in the world economy. During this time, each additional ton of fertilizer applied boosted grain output 9 tons. (See Table 10–3.)

But 1984 was the last year in which a large increase in fertilizer use led to a comparable gain in world grain output. During the next five years farmers continued to use more fertilizer, but their crops did not respond much. Each additional ton of fertilizer used raised grain output by less than 2 tons. Given such a weak response, applying more fertilizer was clearly not a money-making proposition. Farmers' reaction, both predictable and rational, was to use less. Between 1989 and 1993, they cut fertilizer use some 12 percent. Even excluding the precipitous drop in the former Soviet Union following economic reforms, usage elsewhere dropped by 3 percent.[24]

The phenomenal growth in fertilizer use from 1950 to 1984 was due in part to the record growth in irrigation from 1950 to 1978. Since then, however, irrigation has expanded at scarcely 1 percent a year. And new varieties that would respond strongly to still heavier applications of fertilizer have not been developed. Restoring rapid, sustained growth in fertilizer use and, hence, in the world grain harvest is not likely unless someone can develop varieties of wheat, corn, and rice that are far more responsive to fertilizer than those now available.[25]

Failure to recognize this recent slowdown in yield gains and the reasons for it can generate overly optimistic projec-

Table 10–3. World Grain Production and Fertilizer Use, 1950–93

Year	Grain Production	Increment	Fertilizer Use[1]	Increment	Incremental Grain/Fertilizer Response[1]
	(million tons)				(ratio)
1950	631		14		
1984	1,649	1,018	126	112	9.1
1989	1,685	36	146	20	1.8
1993	1,719	34	130	−16	—[2]

[1]Assumes that all fertilizer is used for grain; although this is obviously not the case, it provides a broad picture of the changing response. [2]Incremental ratio cannot be calculated because fertilizer use declined
SOURCE: U.N. Food and Agriculture Organization, *Fertilizer Yearbook* (Rome: various years); International Fertilizer Industry Association, *Fertilizer Consumption Report* (Paris: 1992); U.S. Department of Agriculture, *World Grain Database* (unpublished printout) (Washington, D.C.: 1993).

tions. In a forthcoming study entitled *The World Food Outlook: Malthus Must Wait*, World Bank economists Donald O. Mitchell and Merlinda D. Ingco project world food supply and demand to 2010, assuming that the rate of growth in grain yield per hectare between 1960 and 1990 will simply continue until 2010. This makes for a rather hopeful set of projections. Unfortunately, there is no scientific foundation for this assumption, given the dramatic slowdown in the rise of grain yield per hectare during the late eighties and early nineties. Indeed, from 1990 to 1993, the first three years in the 20 years projected, worldwide grain yield per hectare actually declined.[26]

Donald Plucknett of the Consultative Group on International Agricultural Research presented a paper in late 1993 in which he argues there is no evidence of a slowdown in the rise in grain yields. Looking at both longer-term yield trends and those from 1980 to 1990, he notes that yields have increased substantially in almost every country. This is not debatable. But both these analyses miss the abrupt deceleration in the rise in yields that has occurred since 1984—from a 2.3-percent annual increase in grain yield per hectare between 1950 and 1984 to a mere 1-percent annual increase from 1984 to 1993.[27]

Environmental degradation is also slowing the rise in yields. The earlier rapid rise in fertilizer use may have obscured the negative effects on yields of soil erosion, air pollution, waterlogging and salting, and other forms of degradation. But where fertilizer use is no longer rising, these effects may become more visible.

Few countries that have doubled or tripled grain yields during the last several decades can expect to match that record during the next few with existing technologies. Most have either already achieved the easy dramatic rises or lack the natural conditions needed to do so. In semiarid Africa, for example, where yields have risen little, the prospects for sharply raising output during the next four decades are no better than they were for Australia's farmers, who boosted wheat yields by less than half between 1950 and 1990. Every country that has multiplied its yields has relied heavily on the same basic combination of water (either from relatively generous

rainfall or from irrigation), fertilizer, and grain varieties that are highly responsive to fertilizer.[28]

In one sense, it is surprising that the rise in yields is slowing in so many countries at the same time. An analysis of these trends in all countries reveals that the slowdown affects each of the major cereals—wheat, rice, and corn. And it affects rainfed and irrigated crops, temperate and tropical regions, industrial and developing countries. But in another sense, the deceleration is not surprising since farmers everywhere now draw on the same international pool of yield-raising technologies.

In Western Europe, the slowdown came after population had stabilized, but in many developing countries it has occurred while population is still growing rapidly. Not surprisingly, slowly rising grain yields per hectare are a matter of particular concern for countries where massive population gains are projected. These new yield trends help explain why annual growth in the world harvest dropped from an average of 30 million tons from 1950 to 1984 to 12 million tons from 1984 to 1992. If population grows as projected and farmers cannot increase grain output by more than 12 million tons per year, per capita supplies will continue to diminish, dropping from the historical high of 346 kilograms in 1984 to 248 kilograms in 2030. In effect, the next four decades could be a mirror image of the last four, with grain availability levels in 2030 returning to those of 1950. (See Figure 10–6.)[29]

The contrast between mid-century and today in terms of the backlog of agricultural technology could not be more striking. When the fifties began, there was a great deal of technology waiting to be used. Justus von Liebig had discovered in 1847 that all the nutrients extracted from the soil by crops could be replaced in mineral form. Gregor Mendel's work establishing the basic principles of heredity, which laid the groundwork for future crop breeding advances, was done in the 1860s. Basic irrigation technologies had been around for several thousand years. Hybrid corn varieties were commercialized well before mid-century. And the dwarfing of wheat and rice plants in Japan to boost fertilizer responsiveness dates back a century.[30]

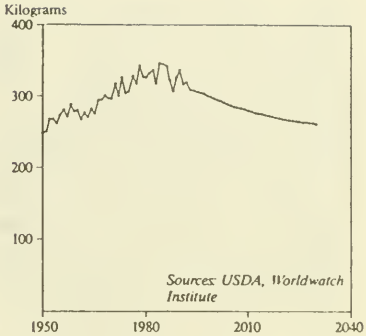


Figure 10-6. World Grain Output Per Person, 1950-93, With Projections to 2030

As these long-standing technologies have been exploited during the last four decades, no new technologies that could lead to quantum leaps in world food output have taken their place. As a result, the nineties begin with the more progressive farmers looking over the shoulders of agricultural scientists seeking new yield-raising technologies only to discover that they have little to offer. The pipeline of new yield-raising agricultural technologies has not run dry, but the flow has slowed to a trickle.[31]

Most future growth in grain output must therefore come from exploiting technologies not yet fully used. Technological advances that could dramatically expand food output include a wholesale reduction in the cost of desalting seawater or the redesign of the photosynthetic process to enable it to convert solar energy into biochemical energy more efficiently. Unfortunately, leading scientific

bodies, such as the National Academy of Sciences and the Royal Society of the United Kingdom, do not hold out much hope for such far-reaching breakthroughs in the foreseeable future.[32]

Some have high hopes that biotechnology will dramatically improve the food prospect. But this is not a panacea. It permits researchers to reach some goals faster and at less cost. And, uniquely, it permits the transfer of germplasm from one species to another. Thus far its contributions have centered more on such things as improving the resistance of crops to insects and diseases. Successes in this area reduce dependence on chemical controls, but they raise production only when the incorporated resistance is more effective than the pesticides previously used. After a small conference involving many of the world's leading agricultural scientists, Vernon Ruttan, an agricultural economist at the University of Minnesota, summarized the group's feeling: "Advances in conventional technology will remain the primary source of growth in crop and animal production over the next quarter century."[33]

During the last decade, the real price of grain has declined somewhat, continuing a long-term trend and leading some to argue that the loss of momentum in food output growth could be reversed by a scarcity-induced price rise. Higher grain prices will undoubtedly stimulate additional investment in agriculture, but whether they will greatly expand output is another question. This will happen only if the higher prices make profitable the expanded use of basic inputs, such as land, water, fertilizer, and more productive varieties. But as noted earlier, the last major effort to expand the world's cropland, in the late seventies, ended in retrenchment. Over the last decade, the world's grain harvested area has actually declined. The reality is that there is simply not much fertile land waiting to be plowed.

Similarly, the global potential for dramatically expanding the irrigated area is constrained by aquifer depletion and the lack of suitable sites for irrigation dams. Expansion of irrigation will continue as new projects are completed, but whether it can expand fast enough to offset the negative effects of waterlogging and salting of existing irrigated area, and make a major net contribution to world food output, is problematic. And with fertilizer, the response curves are such that even if the world's farmers were to double fertilizer use, it would only marginally boost the grain harvest.[34]

Perhaps the best test of the price hypothesis has occurred in Japan, where the government supports rice prices at six times the world market level. Boosting rice yields in Japan is extraordinarily profitable, but try as they might, Japan's farmers—scientifically literate, hard-working, and with access to cheap credit—have not raised rice yields at all over the last decade.[35]

In summary, there are innumerable opportunities for expanding food production, many of them locally unique. But all the identifiable ones are small, adding a little here and a little there. There are no large jumps in output in prospect comparable to those that followed the expanding use of fertilizer or the hybridization of corn. Without such dramatic, broad-based advances, the world's farmers may not be able to restore the rapid steady growth in food output that characterized the period from 1950 to 1984.

National Carrying Capacity Assessments

With grain yields now plateauing in some countries, with national fish catches unlikely to increase much, if at

all, and with rangelands widely overgrazed in most countries, there is an urgent need for national assessments of carrying capacity. Otherwise, there is a real risk that countries will blindly overrun their food carrying capacity, developing massive deficits that will collectively exceed the world's exportable supplies. Recent data showing the level at which the rise in grain yield per hectare is slowing or levelling off in countries with a wide range of growing conditions provide all governments with the reference points needed to estimate the population carrying capacity of their croplands.

China, which already has one of the slowest population growth rates in the developing world, is projected to add 490 million people over the next four decades, increasing to 1.6 billion in 2030. (See Table 10–4.) Currently it is adding 14 million people per year. Meanwhile, its economy is expanding at 10 percent or more annually, fueling steady rises in consumption of pork,

Table 10–4. Population Growth 1950–90, With Projections to 2030, for the Most Populous Countries[1]

Country	1950	1990	2030	Increase 1950–90	Increase 1990–2030
			(million)		
Slowly Growing Countries					
United States	152	250	345	98	95
Russia	114	148	161	34	13
Japan	84	124	123	40	−1
United Kingdom	50	58	60	8	2
Germany	68	80	81	12	1
Italy	47	58	56	11	−2
France	42	57	62	15	5
Rapidly Growing Countries					
Philippines	21	64	111	43	47
Nigeria	32	87	278	55	191
Ethiopia and Eritrea	21	51	157	30	106
Iran	16	57	183	41	126
Pakistan	40	118	260	78	142
Bangladesh	46	114	243	68	129
Egypt	21	54	111	33	57
Mexico	28	85	150	57	65
Turkey	21	57	104	36	47
Indonesia	83	189	307	106	118
India	369	853	1,443	484	590
Brazil	53	153	252	100	99
China	563	1,134	1,624	571	490

[1]Census Bureau data are used because they are updated more often than the U.N. medium-range projections; the two series are usually similar, but small differences do exist.

SOURCE: U.S. Bureau of the Census, in Francis Urban and Ray Nightingale, *World Population by Country and Region, 1950–90 and Projections to 2050* (Washington, D.C.: U.S. Department of Agriculture, Economic Research Service, 1993).

poultry, eggs, and fish—all produced with grain.[36]

On the supply side, rapid industrialization in China, including the construction of thousands of factories during this decade, is consuming vast amounts of cropland even as the rise in per hectare yield of rice and wheat is slowing. The result, according to a detailed study commissioned by the Australian government, is that China's grain imports could go from 12 million tons in 1993 up to 50-100 million tons by the end of this decade, with the latter amount being above current U.S. exports. If China's economy expands as planned and its population grows as projected, its grain import needs are likely to continue to soar, exceeding by 2015 the world's current exportable grain supplies.[37]

India—already faced with extensive soil erosion and falling water tables—will be adding 590 million people by 2030, even more than China, as its population increases to 1.44 billion. With wheat yields that have already tripled and rice yields that are rising more slowly than in the past, India will find it difficult to support these growing numbers.[38]

The United States, though it is the world's third most populous country, has kept demand for grain well below the sustainable yield of its land, maintaining a large exportable surplus. However, with population projected to expand by 95 million as a result of natural increase and immigration during the next four decades, pushing the total to 345 million in 2030, large areas of farmland will be claimed for housing, schools, and shopping centers. Unless some way can be found to reestablish the rapid rise in yields that prevailed from 1950 to 1984, the exportable grain surplus—which dropped from 100 million tons in the early eighties to 70 million tons in the early nineties as consumption climbed and as highly erodible cropland was converted to grassland—may well continue to fall.[39]

Ethiopia was unable to expand grain production fast enough to keep pace with the 30 million people added between 1950 and 1990. Now it is projected to add, in the next four decades, 106 million people—which would triple its 1990 population. Few believe this will happen. The only question is whether the projected growth will not materialize because the transition to smaller families accelerates or because starvation checks the growth.

For Nigeria, the situation is scarcely any more comforting. After adding 55 million people from 1950 to 1990, Nigeria is projected to add 191 million by 2030. With soils that are already heavily eroded, it is difficult to see how crop yields can rise enough to accommodate this tripling of population to 278 million.

An environmental assessment for Pakistan noted that the nation's population is projected to reach 400 million.

Mexico, facing severe water scarcity, is projected to add 65 million people during the next four decades, compared with 57 million in the last four. Wheat yields there have already plateaued, showing no increase in the last nine years. Although there is still an unrealized potential for raising corn yields, it is difficult to see how Mexico can stop its annual grain deficit from rising far beyond the 5 million tons of recent years.[40]

Such projections can be invaluable to national governments. An environmental assessment for Pakistan undertaken with the assistance of IUCN–The World Conservation Union noted that the na-

tion's population is projected to reach 400 million. The report pointed out that while Pakistan might accommodate an increase from its current 121 to 200 million, it could not go much beyond that. If it remains on the trajectory of 400 million Pakistanis, it "will become an international charity case—like Haiti, Ethiopia, Sudan, and Bangladesh—dependent on the good will of others, with no realistic opportunity to improve the lot of its people and no expectations other than the continual decline of living standards for the vast bulk of them." This set of projections gives the government the information needed to establish a public dialogue on choices in the trade-off between family size and consumption levels.[41]

Aside from the obvious value to governments of doing such assessments, these studies collectively give a sense of the future relationship between import needs and exportable supplies. During the past decade, world grain exports totalled roughly 200 million tons annually, with close to half coming from the United States. The other half came from Argentina, Australia, Canada, France, South Africa, and Thailand. With world grain exports even more concentrated than those of oil, the risk that a U.S. crop shortfall presents to the more than 100 grain-importing countries is clear. Although exportable supplies could well decline during the next four decades, particularly if farm subsidies are reduced, import needs are expected to soar in countries where the projected population increase of 3.6 billion is concentrated.[42]

Even while national carrying capacity assessments are under way, a global set of projections is needed, one that draws on them and analyzes the human carrying capacity of the planet. Without this global effort, countries with soaring import needs will have no way of knowing whether exportable supplies will be available. This assessment could be used as a basis for international discussion. And, like national studies, it should be updated every two years or so, taking into account the availability of new farming technologies, fresh evidence of the effects of environmental degradation on food production, and the most recent data on population growth.

Carrying capacity projections at the global level give a sense of global options as well. For example, the world grain output projections discussed earlier assumed annual growth of 12 million tons, yielding a harvest in 2030 of 2.2 billion tons. This could satisfy populations of varying sizes, depending on consumption levels. At the U.S. consumption level of 800 kilograms per person a year, such a harvest would sustain 2.75 billion people—half as many as are alive today. At the Italian consumption level of 400 kilograms, it would support 5.5 billion people, the 1993 world population. And at the Indian level of 200 kilograms, it would support 11 billion people. Although much of humanity aspires to the U.S. diet, population growth has foreclosed that option.[43]

At its peak of 346 kilograms in 1984, world grain output per person was well above the 300 kilograms of China and climbing toward the 400 kilograms of Italy. But that trend has been reversed. The harvest for 2030 of 2.2 billion tons would provide an average of 248 kilograms for each of the 8.9 billion people projected for that year—28 percent below the historical high. Stated otherwise, average grain consumption per person in 2030 would be well below that of China today, and falling toward that of India. Coming at a time when U.N. estimates show nearly 1 billion people in developing countries already failing to get enough calories to maintain normal levels of physical activity and when 36 percent of all preschool children in developing countries are below weight for

their age, this prospective decline is not a pleasant one.[44]

Treading More Lightly

In low-income countries, where diets are often dominated by a single starchy staple, rises in income quickly translate into consumption of more livestock products. This rise in animal protein intake, which both improves nutrition and adds variety to an otherwise monotonous diet, is widely seen as an early sign of progress. When asked by a *New York Times* reporter if living conditions were improving, a Chinese villager responded, "Overall life has gotten much better. My family eats meat maybe four or five times a week now. Ten years ago we never had meat."[45]

Thus as incomes rise, so does grain use. In low-income countries, grain consumption per person averages some 200 kilograms a year, roughly one pound per day. (See Table 1–2 in Chapter 1.) At this level, diets are high in starch and low in fat and protein, with up to 70 percent or more of caloric intake coming from one staple, such as rice.[46]

By contrast, individuals in affluent societies such as the United States consume some 800 kilograms of grain a year, the bulk of it indirectly in the form of beef, mutton, pork, poultry, milk, cheese, yogurt, ice cream, and eggs. Grain use tracks income upward until it reaches this level, producing a grain-consumption ratio between those living in the world's wealthiest and poorest countries of roughly four to one.[47]

The 800 kilograms of grain consumed per person each year in the United States translates into a diet rich in livestock products: as meat, it includes 42 kilograms of beef, 28 kilograms of pork, and 44 kilograms of poultry. (See Table 10–5.) From dairy cows, it includes 271 kilograms of milk, part of it consumed directly and part as cheese (12 kilograms), yogurt (2 kilograms), and ice cream (8 kilograms). Rounding out this protein-rich fare are more than 200 eggs a year.[48]

This contrasts sharply with the situation in India, where most of the 200 kilo-

Table 10–5. Per Capita Grain Use and Consumption of Livestock Products in Selected Countries, 1990

Country	Grain Use[1]	Consumption						
		Beef	Pork	Poultry	Mutton	Milk[2]	Cheese	Eggs
	(kilograms)	(kilograms)						
United States	800	42	28	44	1	271	12	16
Italy	400	16	20	19	1	182	12	12
China	300	1	21	3	1	4	—	7
India	200	—	0.4	0.4	0.2	31	—	13

[1]Data rounded to nearest 100 kilograms, as the purpose here is to contrast the wide variation in consumption of livestock products associated with different levels of grain use. [2]Total consumption, including that used to produce cheese, yogurt, and ice cream.

SOURCE: U.N. Food and Agriculture Organization, *FAO Production Yearbook 1990* (Rome: 1991).

grams of grain available per person are eaten directly just to meet basic food energy needs. With little grain available to feed livestock and poultry and with a limited cultural acceptance of beef, consumption of livestock products is low. For the average Indian, it totals 31 kilograms of milk; 1 kilogram of pork, poultry, and mutton combined; and about 170 eggs.

In between the United States and India are Italy, using 400 kilograms of grain per person annually, and China, with 300 kilograms. The big difference between the United States and Italy is meat consumption: 115 kilograms per year versus 56. And just as India matches the industrial countries in egg consumption per person, China nearly equals them in consumption of pork, its most popular livestock product. Among these four countries, life expectancy is highest in Italy—perhaps in part because it may have the healthiest all-around diet, one where animal protein intake is high enough that even the poor are adequately nourished but not so rich in animal fats that it damages health.[49]

As the demand for meat rises, growth in supply is shaped in part by how efficiently various species convert grain into meat. For cattle in the feedlot, it takes roughly 7 kilograms of grain to add a kilogram of live weight. For pork, it takes roughly 4 kilograms. Poultry and fish are much more efficient, requiring 2 kilograms for each kilogram of live weight gain. Cheese and eggs are in between, requiring 3.0 and 2.6 kilograms of grain, respectively.[50]

The worldwide use of grain for feed, which includes the by-products of grain milling, such as rice bran, climbed from 289 million tons in 1960 to 650 million tons in 1986, accounting for 40 percent of total grain use, an all-time high. (See Figure 10–7.) Since then, the amount of grain used for feed has actually declined, dropping to 37 percent of world grain use in 1992. This reflects a shift toward

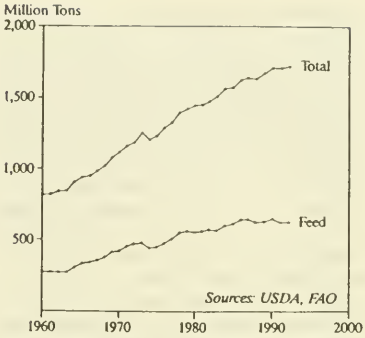


Figure 10-7. World Grain Use, Total and for Feed, 1960–92

the more efficient meats, such as poultry, along with a worldwide fall in incomes since 1990, including a particularly sharp drop in Eastern Europe and the former Soviet Union.[51]

Contrary to popular impressions, a large share of world feedgrain use occurs in the Third World. The two countries that feed the most grain to livestock, poultry, and fish are the United States and China—160 and 140 million tons, respectively.[52]

For health reasons alone, people in the most affluent societies should reduce consumption of fat-rich livestock products. The question is how. If governments in these societies want to lower consumption to improve health and to free up grain for the world's poor, they can do it through public education and exhortation, through taxing consumption of livestock products, or through rationing. Scarcity-induced price rises can also cut the amount of livestock products people eat. Following the doubling of world grain prices between 1972 and 1973, for example, total grain use in the United States dropped from 178 million to 136 million tons. Relying on the market to reduce grain use among the affluent through scarcity-induced price rises, however, could threaten the survival of millions in low-income countries who al-

ready spend most of their income on food.[53]

No modern society has voluntarily reduced consumption of livestock products by a meaningful amount. Any such drops have been the result of sharply rising prices, as in the United States during the mid-seventies; wartime rationing, as in the United Kingdom during World War II; or the removal of food subsidies, as in the former Soviet Union during the early nineties.

Once feedgrain use is reduced, whether by rationing, taxing, or another means, a way must be found to finance its purchase and distribution to those who are hungry. No one knows how much food could be redistributed internationally. Since 1980, some 10–11 million tons of grain have been shipped annually as aid from all sources, most of it under the auspices of the U.S. Food for Peace Program and the U.N. World Food Programme. At issue is whether this could be greatly expanded to alleviate hunger if massive shortages emerge.[54]

Would the earth's more affluent be willing to greatly simplify their diets for a one-time gain in consumption elsewhere? And could governments in industrial countries finance a far greater redistribution of food at a time when fiscal stringencies are reducing foreign aid budgets? Could the United Nations respond to massive famine threats in several countries simultaneously? In the absence of some major changes, it would be unwise for countries facing potential food deficits to assume that food aid would automatically be available to cover their shortfalls.

Stabilizing Our Numbers

New information on the carrying capacity of both land and oceanic food systems argues for a basic rethinking of national population policies, for an accelerated international response to unmet family planning needs, and for the recasting of development strategies to address the underlying causes of high fertility. As national demands cross the sustainable-yield thresholds of biological support systems, the resource base itself is being consumed. In this situation, the question may not be what rate of population growth is sustainable but whether growth can continue without reducing living standards. Even now, the food needs of the 90 million added each year can be satisfied only by reducing consumption among those already here.

Perhaps the greatest gap in formulating population policy has been the failure to consider carrying capacity.

In a world where the cropland area is not expanding, grain yield per hectare has to rise as fast as population growth merely to maintain the existing inadequate supply of food. But with the rise in yields slowing so dramatically, reversing the decline in per capita grain production under way since 1984 may now depend on quickly slowing population growth. Otherwise, hunger may continue to spread, claiming more and more lives.

Perhaps the greatest gap in formulating population policy has been the failure to consider carrying capacity. If national governments calculate the food carrying capacity of their countries, they can integrate this analysis into population policy. Few national political leaders even use the term carrying capacity, much less incorporate the concept in policymaking. The national carrying capacity assessments discussed earlier, outlining the potential social costs of

carrying capacity overruns, could mobilize public support for quickly moving to smaller families.

If people know that maintaining current family size will reduce cropland area per person by a third or half during the next generation, they can see what that will mean for their children. If they know that large families will almost certainly bring more hunger, and even mass starvation, they may well decide to shift to smaller families. People can understand the central importance of population policy if it is put in terms they can relate to.

People need to know the longer term consequences of having an average of, say, six children, four children, or two children. Couples who have this information may realize that the key question is no longer "How many children should I have for my old age security?" but "How will the number of children I have affect the world in which they live?" Since people everywhere do care about their children, answering this question can spawn an important shift in thinking, one with a potentially profound effect on family size decisions. If population policy is not grounded in public discussion of these options, it is not likely to succeed.

For countries that decide to accelerate the shift to smaller families, the challenge is to provide the needed family planning services. The first, perhaps most obvious step is to fill the family planning gap. The fact that more than 100 million women in the Third World want to limit the number of children they have but lack the means to do so is inexcusable. The restoration of U.S. funding for the U.N. Population Fund announced in early 1993 is a step in the right direction.[55]

The basic ingredients in a strategy to slow population growth are well known to governments and the international community, and will not be repeated at length here. The most successful programs provide a cafeteria approach to services by including the entire range of contraceptives so that individual needs are most fully satisfied. Each country where population has stabilized thus far, all in Europe, has had a wide range of family planning services backed up by abortion in the event of a contraceptive failure.[56]

Even as the family planning gap is being filled, there is an equally urgent need to improve the status of women, particularly in developing countries, where females suffer discrimination from birth. High on the agenda are increasing access to reproductive health care and raising the level of female literacy. In addition, any strategy that reduces poverty sets the stage for a shift to small families.[57]

What is missing in this strategy to reduce human fertility is a broad-based public commitment to do so. There is little recognition that the nature of the population threat has changed in recent years: continuing rapid population growth once slowed the rise in living standards; now it is lowering them for much of humanity.

Given the limits to the earth's carrying capacity, every national government needs a carefully articulated population policy, one that takes into account their carrying capacity at whatever consumption level citizens decide on. As Harvard biologist Edward O. Wilson observes in his landmark book *The Diversity of Life*, "Every nation has an economic policy and a foreign policy. The time has come to speak more openly of a population policy. By this I mean not just the capping of growth when the population hits the wall, as in China and India, but a policy based on a rational solution of this problem; what, in the judgment of its informed citizenry, is the *optimal* population?"[58]

In the end, only national governments

can assume the responsibility of feeding their people, only they can formulate the agricultural and population policies that will ensure an adequate diet for all their people. The international community can support national initiatives, but it cannot replace them.

A Test of Civilization

Humanity faces many challenges as this century nears its end, but none looms larger than that of reversing the fall in grain production per person that has been under way since 1984. If this decline continues indefinitely, it will lead to political instability and social disintegration of the sort seen in Somalia, the Sudan, and Haiti. This trend is a test of our political institutions—indeed, of our humanity and modern civilization.

The drop in grain output per person is not merely an agronomic trend; it is an indicator of the crisis emerging between us, now 5.5 billion in number, and the natural systems and resources that support us. It is a systemic threat that requires a systemic response.

After nearly four decades of rapidly rising cropland productivity, many assumed that this trend would continue indefinitely. Unfortunately, it will not. Environmentalists, long concerned by a potential deterioration in the balance between food and people, are now being joined by the scientific community. Its leaders, observing the shrinking backlog of yield-raising agricultural technologies and the cumulative effects of the environmental degradation on agriculture, have started to speak out. In early 1992, the U.S. National Academy of Sciences and the Royal Society of London warned in an unprecedented joint statement that advances in science and technology no longer could be counted on to avoid either irreversible environmental degradation or continued poverty for much of humanity.[59]

Later in the year, the Union of Concerned Scientists issued a "World Scientists Warning to Humanity" signed by some 1,600 of the world's leading scientists, including 102 Nobel Prize winners. It observes that the continuation of destructive human activities "may so alter the living world that it will be unable to sustain life in the manner that we know." And the scientists warned: "A great change in our stewardship of the earth and the life on it is required, if vast human misery is to be avoided and our global home on this planet is not to be irretrievably mutilated."[60]

A systemic response to the deteriorating food situation depends heavily on slowing population growth, halting the degradation of the natural systems that support agriculture, and boosting investments in agriculture. As noted earlier, the keys to slowing population growth are filling the family planning gap, raising the status of women, and reducing poverty, the latter long an elusive goal of development strategists.

Protecting agriculture's support systems includes reducing soil losses from erosion below the natural rate of soil formation, preserving its biologically diverse germplasm base, and protecting the ozone layer to avoid increases in crop-damaging ultraviolet radiation. Food security also depends on stabilizing climate and reducing crop damage from air pollution. Both of these in turn require the phaseout of fossil fuels.

If there are no quantum jumps in world food output in prospect, such as those that came from the expanding use of fertilizer or the adoption of hybrid corn, it will be far more difficult to expand food output in the future. The era when applying another million tons of fertilizer would boost the world grain harvest by 9 million tons may now be

history. Future gains in output have to come from more localized technological advances, a little here and a little there. Such a situation means spending far more on agricultural research. In a water-scarce world, it means investing heavily in irrigation water efficiency as a way of expanding irrigation. And every little gain in output is needed: 82,000 tons of additional grain satisfies growth in world demand for a day, buying one more day to slow population growth.

The new information on the earth's carrying capacity brings with it a responsibility to educate and to act that, until recently, did not exist.

The combination of falling grain output per person and a shrinking seafood catch per person is taking the world into uncharted economic territory. Glimpses of the new future can be seen in the rising prices in fresh-seafood shops, in the spreading hunger in Africa, and in the growing nervousness about the adequacy of future water supplies in the Middle East. At the most fundamental level, we need to recognize that we are approaching a potential crisis and that we need to respond on an appropriate scale. The national carrying capacity studies described earlier, using the most recent population projections and the latest information on sustainable yields of fisheries, grasslands, and croplands, can help fill the gap in our collective understanding. For countries needing help preparing such reports, the logical sources are the World Bank and the bilateral aid agencies.

Seldom has the world faced an unfolding emergency whose dimensions are as clear as the growing imbalance between food and people. The new information on the earth's carrying capacity brings with it a responsibility to educate and to act that, until recently, did not exist. A massive global environmental education effort, one in which the communications media are heavily involved, may be the only way to bring about the needed actions in the time available.

Ensuring future food security is an all-encompassing undertaking that will require far more attention from leaders and a greater commitment of public resources than even the cold war did. Aside from the military sectors of the superpowers, the day-to-day involvement of most people in the cold war was negligible. By contrast, restoring a rise in grain output per person will require the involvement of nearly all of humanity, either in reducing birth rates, expanding food production, or both.

Some of the components required in this effort to stem and reverse the tide of spreading hunger are becoming clear. For example, improved literacy plays an important role not only because among females it correlates closely with reducing fertility, but also because for farmers it is often the key to the adoption of more sophisticated agricultural management practices. At a time when some planners are already worrying about computer literacy in the Third World, hundreds of millions of people still lack the rudimentary skills to take advantage of Gutenberg's printing press, invented some five centuries ago. A U.N.-led effort to achieve universal literacy, patterned after its highly successful effort to promote childhood immunizations, could appeal to the ideals and energy of young people throughout the world.[61]

If the world were to collectively address the population issue on a scale commensurate with the human suffering that is almost inevitable if rapid growth continues, population-related issues would dominate national cabinet meetings and the U.N. General Assembly. World leaders would speak out on the

issue, urging couples everywhere to stop at replacement-level fertility, essentially two surviving children per couple. In discussions among world leaders, changes in birth rates would get at least as much attention as changes in interest rates. Gains in female literacy would rank in importance with gains in savings rates. Governments would report monthly changes in birth rates with the same diligence and concern that they now report changes in the unemployment rate.

Although it is hard to overestimate the difficulty of reversing the deteriorating food/population balance, it can be reversed. Abrupt change is possible. Images flashing across television screens in recent years of the Berlin Wall coming down, of Nelson Mandela leaving prison, and of Yasir Arafat and Yitzhak Rabin shaking hands remind us that sudden change can happen, that we can reverse the deteriorating food situation. Other signs of hope include the new administrations in Tokyo and Washington. Leaders in both governments represent a new generation, one that is more globally aware and environmentally conscious than their predecessors were. The newly elected Parliament in Japan, its ranks liberally sprinkled with women and young people in their twenties, includes many environmentalists. With four women now serving in the Japanese cabinet, the perspective of that powerful body has broadened dramatically.[62]

In Washington, President Clinton was quick to sign the biodiversity treaty from the 1992 Earth Summit, reversing the Bush administration's position. His decision to join other countries in committing to limit year-2000 carbon emissions to their 1990 level was also a major step forward. These and other initiatives indicate that the United States is reassuming a global environmental and population leadership role, something essential to an effective global address of the complex set of issues associated with falling food production per person. Perhaps the most logical next step for the United States would be to lead an international effort to fill the family planning gap, to get services to more than 100 million women who want to limit the size of their families but lack the means to do so. Congress, which has already approved an increase in funding for international family planning assistance of $40 million for fiscal year 1994, would almost certainly support such an initiative.[63]

The question at this hinge point in history is a simple one. Can we mobilize to reverse the continuing decline in food production per person that now clouds the future of civilization? If we start thinking seriously about what it will take to do this, then we may also begin to understand how different the future will be from the recent past.

What will future historians write of us? Will they say that we were the generation whose selfish pursuit of materialism and inability to limit family size put civilization at risk? Or will they say that the initiatives that we took in the nineties put the world on an environmentally sustainable path? Only we can provide the answer.

Biographical Sketch

LESTER R. BROWN

Lester R. Brown, recipient of a $250,000 MacArthur Foundation "genius award" and winner of the United Nations' 1989 environment prize, has been described by the Washington Post as "one of the world's most influential thinkers." The Telegraph of Calcutta called him "the guru of the global environmental movement."

The Library of Congress has requested Brown's personal papers and manuscripts, recognizing the role of his work and that of the Institute under his direction in shaping the global environmental movement of the late twentieth century.

Brown started his career as a farmer, growing tomatoes in southern New Jersey with his younger brother during high school and college. Shortly after earning a degree in agricultural science from Rutgers University in 1955, he spent six months living in rural India. In 1959 Brown left farming to join the U.S. Department of Agriculture's Foreign Agricultural Service as an international agricultural analyst.

Brown has an M.S. in agricultural economics from the University of Maryland and an M.P.A. from Harvard. In 1964, he became an adviser to Secretary of Agriculture Orville Freeman on foreign agricultural policy. In 1966, the Secretary appointed him Administrator of the department's International Agricultural Develop-

ment Service. At the beginning of 1969, he left government to help James Grant, now the head of UNICEF, establish the Overseas Development Council.

In 1974, with support of the Rockefeller Brothers Fund, Lester Brown founded the Worldwatch Institute, a private non-profit research institute devoted to the analysis of global environmental issues. Based in Washington, DC, the Institute is widely known for the Worldwatch Papers, a monograph series.

In 1984, a decade after founding the Institute, Brown launched the State of the World reports. These annual assessments, now translated into more languages than the Reader's Digest, have become the Bible of the global environmental movement. Translated into all the world's major languages—Chinese, Japanese, Spanish, French, Russian, Arabic, Portuguese Indonesian, German, Polish, and Italian—State of the World has now achieved a semi-official status.

In 1988, Brown expanded Worldwatch's publications by launching World Watch, a bimonthly magazine featuring articles on the Institute's research. In 1991, the Institute inaugurated the Environmental Alert book series, with a book Brown coauthored entitled Saving the Planet: How to Shape an Environmentally Sustainable Global Economy. And in 1992, he launched a new annual: Vital Signs: The Trends That Are Shaping Our Future, coauthored by Christopher Flavin and Hal Kane.

The recipient of a string of honorary degrees, he is in worldwide demand as a speaker. Author of a dozen books, including Man, Land and Food, World Without Borders, By Bread Alone, and Building a Sustainable Society, he is the publisher of World Watch, project director and co-author of the annual State of the World series, and project director of the Environmental Alert series.

POVERTY AND POPULATION

Senator BUMPERS. Mr. Brown, this is such a very rich subject, I hardly know where to begin. I started talking about this subject about 5 years ago, and I still speak about it on a regular basis to virtually every audience. You do not get an awful lot of attention, because you know the interest around here in a train wreck depends on the proximity of the wreck. And since, you know, we can probably sustain ourselves a while longer, I personally do not believe—and I am not the demographer that you are—but I strongly suspect that we would have a very difficult time sustaining on a permanent basis more than 2 or 3 billion people.

Mr. BROWN. More people.

Senator BUMPERS. All people on this planet.

Obviously, poverty and population go hand in glove. The poorer a country, the higher the birthrate. And one of the reasons we have not addressed the subject here is, No. 1, it is 30 to 40 years, and I am talking about the real cataclysm, is 30 to 40 years in the future; and, No. 2, there are people who believe the Malthusian theory will take care of the problem for us, either through AIDS or nuclear war or some other cataclysmic event; and, No. 3, the decisions are very, very tough. And to make those things in isolation, for example, in the United States, without addressing the problem globally, does not do very much.

But one of the reasons this interests me is because I see it would be just a worldwide holocaust if we do not address it.

If we are going to have 10 billion people by, say, the year 2040—and there are some people who feel that that is not an exaggeration—you know, we have nothing but social chaos in front of us as a world. What is going on in Yugoslavia is what is going on all over the world. You have essentially an ethnic/religious fight that I can tell you, down the pike, we are going to revert back to what earlier wars were about, and that is food and natural resources.

I think, for the foreseeable future, that in the immediate future: Wars are going to be fought along religious and ethnic grounds.

But the wars after that are going to be fought between nations, between the haves and the have-nots.

And when you think about the social consequences of doing nothing, which is essentially what the world is doing—and you cannot solve the problem in isolation—the United States cannot solve the problem. Italy and Japan can prolong their problems because they are the only two nations which have a less-than-zero population growth rate.

But, at some point, and it has already begun, all of Latin America is struggling, trying to swim the oceans, just as the Haitians are, to get to this country. And for what? Something to eat.

When you look at some of the charts you have in your book here and you see what is happening to arable land in the country—it is being overgrazed all over the world. And people want a protein diet, they want meat and they want eggs and those kinds of things. And, so far as I can see, and based on my own studies of this, we have gone about as far as we can go in increasing cropland.

You know what happened in the Amazonian Basin. I went down there to look at that. What a travesty. Destroying a rain forest, which is essential to our survival, for 1 or 2 years production. And that, not very great. But that is what is happening all over South America, and that is what is happening all over Africa.

And then, you did not talk very much about the fact that as the environment is further pressured by population growth and our efforts to sustain that population growth, we have already probably gone beyond—in most areas of the world, we have gone beyond what we can get by additional herbicides and pesticides. And that presents another environmental problem.

We are getting ready to debate the reauthorization of the Clean Water Act here. And we are going to be dealing with wetlands. We are going to be dealing with herbicides and pesticides, nonpoint source pollution, all of those things. But you are not going to get an awful lot of increase in most—certainly not in the developing nations of the Earth—you are not going to get very much increased production from herbicides and pesticides and fertilizers, because we are already using about all you can use.

I suppose my first question, which is a sort of a macro question, if I were going to ask you if you were king of the world, how would you assemble and whom would you assemble, to start addressing this problem?

One of the reasons nobody pays any attention to me in the Congress is not because I am not shouting loud enough, but it is because you cannot deal with this without talking about family planning and curbing population increases. And that takes you immediately to the abortion issue.

This is not an abortion issue. It is a family planning issue. But most people would rather sit and watch the world population double over the next 50 years, with cataclysmic results, than to sit down and talk about the nitty-gritty things that have to be talked about that we would rather not. And it may be that AIDS will solve the problem for us. That is one hell of a solution, as far as I am concerned, but that may happen.

Or you might have a nuclear war. You might have big earthquakes. You might have a lot of things that will wipe out a signifi-

cant part of the population of the world. It is not unthinkable, certainly.

But, assuming that we are going to be rational, sensible people and really try to deal with this problem, how and where would you begin, and with whom?

Mr. BROWN. I think I would begin by making the point that I think, as you do, that this is going to become the issue. This is going to become security in many different forms, whether it is economic stability or whether it is political stability. And I do not think we have quite—I mean, we still have the cold war mentality in that we are still spying on the Russians as though they were the real threat.

Senator BUMPERS. They are doing a little spying of their own, are they not?

Mr. BROWN. Yes.

But the point is that we are moving into a period that is very different from the four decades in which you and I have spent our professional lives—indeed, most of us. It is going to be very different. And we do not have much experience in analyzing the relationship between the carrying capacity of the Earth's ecosystem and its various components, and the demographic trends, and the economic effects of the interaction of those, and then, the political fallout from that.

There is an article that you may have seen. It is the cover story in the February issue of "The Atlantic Monthly" by Robert Kaplan, called "The Coming Anarchy." If you have not seen it, I would be happy to get a copy of it to you.

Senator BUMPERS. I wish you would; "The Coming Anarchy"?

[The article follows:]

[From The Atlantic Monthly, February 1994]

THE COMING ANARCHY

(By Robert D. Kaplan)

How scarcity, crime, overpopulation, tribalism, and disease are rapidly destroying the social fabric of our planet

THE Minister's eyes were like egg yolks, an aftereffect of some of the many illnesses, malaria especially, endemic in his country. There was also an irrefutable sadness in his eyes. He spoke in a slow and creaking voice, the voice of hope about to expire. Flame trees, coconut palms, and a ballpoint-blue Atlantic composed the background. None of it seemed beautiful, though. "In forty-five years I have never seen things so bad. We did not manage ourselves well after the British departed. But what we have now is something worse—the revenge of the poor, of the social failures, of the people least able to bring up children in a modern society." Then he referred to the recent coup in the West African country Sierra Leone. "The boys who took power in Sierra Leone come from houses like this." The Minister jabbed his finger at a corrugated metal shack teeming with children. "In three months these boys confiscated all the official Mercedes, Volvos, and BMWs

Right: outside Monrovia, Liberia, civilian victims of civil war, dumped near the airport. Far right: government troops in Sierra Leone reoccupy a rebel position

PATRICK FORBES/SYGMA

and willfully wrecked them on the road." The Minister mentioned one of the coup's leaders, Solomon Anthony Joseph Musa, who shot the people who had paid for his schooling, "in order to erase the humiliation and mitigate the power his middle-class sponsors held over him."

Tyranny is nothing new in Sierra Leone or in the rest of West Africa. But it is now part and parcel of an increasing lawlessness that is far more significant than any coup, rebel incursion, or episodic experiment in democracy. Crime was what my friend—a top-ranking African official whose life would be threatened were I to identify him more precisely—really wanted to talk about. Crime is what makes West Africa a natural point of departure for my report on what the political character of our planet is likely to be in the twenty-first century.

The cities of West Africa at night are some of the unsafest places in the world. Streets are unlit; the police often lack gasoline for their vehicles; armed burglars, carjackers, and muggers proliferate. "The government in Sierra Leone has

MIKE GOLDWATER NETWORK/MATRIX

no writ after dark," says a foreign resident, shrugging. When I was in the capital, Freetown, last September, eight men armed with AK-47s broke into the house of an American man. They tied him up and stole everything of value. Forget Miami: direct flights between the United States and the Murtala Muhammed Airport, in neighboring Nigeria's largest city, Lagos, have been suspended by order of the U.S. Secretary of Transportation because of ineffective security at the terminal and its environs. A State Department report cited the airport for "extortion by law-enforcement and immigration officials." This is one of the few times that the U.S. government has embargoed a foreign airport for reasons that are linked purely to crime. In Abidjan, effectively the capital of the Côte d'Ivoire, or Ivory Coast, restaurants have stick- and gun-wielding guards who walk you the fifteen feet or so between your car and the entrance, giving you an eerie taste of what American cities might be like in the future. An Italian ambassador was killed by gunfire when robbers invaded an Abidjan restaurant. The family of the Nigerian ambassador

SIERRA LEONE IS A MICROCOSM OF WHAT IS OCCURRING IN WEST AFRICA AND MUCH OF THE UNDER-DEVELOPED WORLD: THE WITHERING AWAY OF CENTRAL GOVERNMENTS, THE RISE OF TRIBAL AND REGIONAL DOMAINS, THE UNCHECKED SPREAD OF DISEASE, AND THE GROWING PERVASIVENESS OF WAR.

was tied up and robbed at gunpoint in the ambassador's residence. After university students in the Ivory Coast caught bandits who had been plaguing their dorms, they executed them by hanging tires around their necks and setting the tires on fire. In one instance Ivorian policemen stood by and watched the "necklacings," afraid to intervene. Each time I went to the Abidjan bus terminal, groups of young men with restless, scanning eyes surrounded my taxi, putting their hands all over the windows, demanding "tips" for carrying my luggage even though I had only a rucksack. In cities in six West African countries I saw similar young men everywhere—hordes of them. They were like loose molecules in a very unstable social fluid, a fluid that was clearly on the verge of igniting.

"You see," my friend the Minister told me, "in the villages of Africa it is perfectly natural to feed at any table and lodge in any hut. But in the cities this communal existence no longer holds. You must pay for lodging and be invited for food. When young men find out that their relations cannot put them up, they become lost. They join other migrants and slip gradually into the criminal process."

"In the poor quarters of Arab North Africa," he continued, "there is much less crime, because Islam provides a social anchor: of education and indoctrination. Here in West Africa we have a lot of superficial Islam and superficial Christianity. Western religion is undermined by animist beliefs not suitable to a moral society, because they are based on irrational spirit power. Here spirits are used to wreak vengeance by one person against another, or one group against another." Many of the atrocities in the Liberian civil war have been tied to belief in *juju* spirits, and the BBC has reported, in its magazine *Focus on Africa*, that in the civil fighting in adjacent Sierra Leone, rebels were said to have "a young woman with them who would go to the front naked, always walking backwards and looking in a mirror to see where she was going. This made her invisible, so that she could cross to the army's positions and there bury charms . . . to improve the rebels' chances of success."

Finally my friend the Minister mentioned polygamy. Designed for a pastoral way of life, polygamy continues to thrive in sub-Saharan Africa even though it is increasingly uncommon in Arab North Africa. Most youths I met on the road in West Africa told me that they were from "extended" families, with a mother in one place and a father in another. Translated to an urban environment, loose family structures are largely responsible for the world's highest birth rates and the explosion of the HIV virus on the continent. Like the communalism and animism, they provide a weak shield against the corrosive social effects of life in cities. In those cities African culture is being redefined while desertification and deforestation—also tied to overpopulation—drive more and more African peasants out of the countryside.

A PREMONITION OF THE FUTURE

WEST Africa is becoming *the* symbol of worldwide demographic, environmental, and societal stress, in which criminal anarchy emerges as the real "strategic" danger. Disease, overpopulation, unprovoked crime, scarcity of resources, refugee migrations, the increasing erosion of nation-states and international borders, and the empowerment of private armies, security firms, and international drug cartels are now most tellingly demonstrated through a West African prism. West Africa provides an appropriate introduction to the issues, often extremely unpleasant to discuss, that will soon confront our civilization. To remap the political earth the way it will be a few decades hence—as I intend to do in this article—I find I must begin with West Africa

There is no other place on the planet where political maps are so deceptive—where, in fact, they tell such lies—as in West Africa. Start with Sierra Leone According to the map, it is a nation-state of defined borders, with a government in control of its territory. In truth the Sierra Leonian government, run by a twenty-seven-year-old army captain, Valentine Strasser, controls Freetown by day and by day also controls part of the rural interior. In the government's territory the national army is an unruly rabble threatening drivers and passengers at most checkpoints. In the other part of the country units of two separate armies from the war in Liberia have taken up residence, as has an army of Sierra Leonian rebels. The government force fighting the rebels is full of renegade commanders who have aligned themselves with disaffected village chiefs. A premodern formlessness governs the battlefield, evoking the wars in medieval Europe prior to the 1648 Peace of Westphalia, which ushered in the era of organized nation-states.

As a consequence, roughly 400,000 Sierra Leonians are internally displaced, 280,000 more have fled to neighboring Guinea, and another 100,000 have fled to Liberia, even as

400,000 Liberians have fled to Sierra Leone. The third largest city in Sierra Leone, Gondama, is a displaced-persons camp. With an additional 600,000 Liberians in Guinea and 250,000 in the Ivory Coast, the borders dividing these four countries have become largely meaningless. Even in quiet zones none of the governments except the Ivory Coast's maintains the schools, bridges, roads, and police forces in a manner necessary for functional sovereignty. The Koranko ethnic group in northeastern Sierra Leone does all its trading in Guinea. Sierra Leonian diamonds are more likely to be sold in Liberia than in Freetown. In the eastern

THIS PAGE AND OPPOSITE: BETTY PRESS/WOODFIN CAMP

provinces of Sierra Leone you can buy Liberian beer but not the local brand.

In Sierra Leone, as in Guinea, as in the Ivory Coast, as in Ghana, most of the primary rain forest and the secondary bush is being destroyed at an alarming rate. I saw convoys of trucks bearing majestic hardwood trunks to coastal ports. When Sierra Leone achieved its independence, in 1961, as much as 60 percent of the country was primary rain forest. Now six percent is. In the Ivory Coast the proportion has fallen from 38 percent to eight percent. The deforestation has led to soil erosion, which has led to more flooding and more mosquitoes. Virtually everyone in the West African interior has some form of malaria.

Sierra Leone is a microcosm of what is occurring, albeit in a more tempered and gradual manner, throughout West Africa and much of the underdeveloped world: the withering away of central governments, the rise of tribal and regional domains, the unchecked spread of disease, and the growing pervasiveness of war. West Africa is reverting to the Africa of the Victorian atlas. It consists now of a series of coastal trading posts, such as Freetown and Conakry, and an interior that, owing to violence, volatility, and disease, is again becoming, as Graham Greene once observed, "blank" and "unexplored." However, whereas Greene's vision implies a certain romance, as in the somnolent and charmingly seedy Freetown of his celebrated novel *The Heart of the Matter*, it is Thomas Malthus, the philosopher of demographic doomsday, who is now the prophet of West Africa's future. And West Africa's future, eventually, will also be that of most of the rest of the world.

CONSIDER "Chicago." I refer not to Chicago, Illinois, but to a slum district of Abidjan, which the young toughs in the area have named after the American city. ("Washington" is another poor section of Abidjan.) Although Sierra Leone is widely regarded as beyond salvage, the Ivory Coast has been considered an African success story, and Abidjan has been called "the Paris of West Africa." Success, however, was built on two artificial factors: the high price of cocoa, of which the Ivory Coast is the world's leading producer, and the talents of a French expatriate community, whose members have helped run the government and the private sector. The expanding cocoa economy made the Ivory Coast a magnet for migrant workers from all over West Africa: between a third and a half of the country's population is now non-Ivorian, and the figure could be as high as 75 percent in Abidjan. During the 1980s cocoa prices fell and the French began to leave. The skyscrapers of the Paris of West Africa are a façade. Perhaps 15 percent of Abidjan's population of three million people live in shantytowns like Chicago and Washington, and the vast majority live in places that are not much better. Not all of these places appear on any of the readily available maps. This is another indication of how political maps are the products of tired conventional wisdom and, in the Ivory Coast's case, of an elite that will ultimately be forced to relinquish power.

Chicago, like more and more of Abidjan, is a slum in the bush: a checkerwork of corrugated zinc roofs and walls made of cardboard and black plastic wrap. It is located in a gully teeming with coconut palms and oil palms, and is ravaged by flooding. Few residents have easy access to electricity, a sewage system, or a clean water supply. The crumbly red

The press of population. Right: doing the wash in a lagoon in Abidjan, the Ivory Coast. Left: the nearly impassable downtown of Lagos, Nigeria.

laterite earth crawls with foot-long lizards both inside and outside the shacks. Children defecate in a stream filled with garbage and pigs, droning with malarial mosquitoes. In this stream women do the washing. Young unemployed men spend their time drinking beer, palm wine, and gin while gambling on pinball games constructed out of rotting wood and rusty nails. These are the same youths who rob houses in more prosperous Ivorian neighborhoods at night. One man I met, Damba Tesele, came to Chicago from Burkina Faso in 1963. A cook by profession, he has four wives and thirty-two children, not one of whom has made it to high school. He has seen his shanty community destroyed by municipal authorities seven times since coming to the area. Each time he and his neighbors rebuild. Chicago is the latest incarnation.

Fifty-five percent of the Ivory Coast's population is urban, and the proportion is expected to reach 62 percent by 2000. The yearly net population growth is 3.6 percent. This means that the Ivory Coast's 13.5 million people will become 39 million by 2025, when much of the population will consist of urbanized peasants like those of Chicago. But don't count on the Ivory Coast's still existing then. Chicago, which is more indicative of Africa's and the Third World's demographic present—and even more of the future—than any idyllic junglescape of women balancing earthen jugs on their heads, illustrates why the Ivory Coast, once a model of Third World success, is becoming a case study in Third World catastrophe.

President Félix Houphouët-Boigny, who died last December at the age of about ninety, left behind a weak cluster of political parties and a leaden bureaucracy that discourages foreign investment. Because the military is small and the non-Ivorian population large, there is neither an obvious force to maintain order nor a sense of nationhood that would lessen the need for such enforcement. The economy has been shrinking since the mid-1980s. Though the French are working assiduously to preserve stability, the Ivory Coast faces a possibility worse than a coup: an anarchic implosion of criminal violence—an urbanized version of what has already happened in Somalia. Or it may become an African Yugoslavia, but one without mini-states to replace the whole.

Because the demographic reality of West Africa is a countryside draining into dense slums by the coast, ultimately the region's rulers will come to reflect the values of these shanty-towns. There are signs of this already in Sierra Leone—

and in Togo, where the dictator Etienne Eyadema, in power since 1967, was nearly toppled in 1991, not by democrats but by thousands of youths whom the London-based magazine *West Africa* described as "Soweto-like stone-throwing adolescents." Their behavior may herald a regime more brutal than Eyadema's repressive one.

The fragility of these West African "countries" impressed itself on me when I took a series of bush taxis along the Gulf of Guinea, from the Togolese capital of Lomé, across Ghana, to Abidjan. The 400-mile journey required two full days of driving, because of stops at two border crossings and an additional eleven customs stations, at each of which my fellow passengers had their bags searched. I had to change money twice and repeatedly fill in currency-declaration forms. I had to bribe a Togolese immigration official with the equivalent of eighteen dollars before he would agree to put an exit stamp on my passport. Nevertheless, smuggling across these borders is rampant. *The London Observer* has reported that in 1992 the equivalent of $856 million left West Africa for Europe in the form of "hot cash" assumed to be laundered drug money. International cartels have discovered the utility of weak, financially strapped West African regimes.

The more fictitious the actual sovereignty, the more severe border authorities seem to be in trying to prove otherwise. Getting visas for these states can be as hard as crossing their borders. The Washington embassies of Sierra Leone and Guinea—the two poorest nations on earth, according to a 1993 United Nations report on "human development"—asked for letters from my bank (in lieu of prepaid round-trip tickets) and also personal references, in order to prove that I had sufficient means to sustain myself during my visits. I was reminded of my visa and currency hassles while traveling to the communist states of Eastern Europe, particularly East Germany and Czechoslovakia, before those states collapsed.

Ali A. Mazrui, the director of the Institute of Global Cultural Studies at the State University of New York at Binghamton, predicts that West Africa—indeed, the whole continent—is on the verge of large-scale border upheaval. Mazrui writes,

> In the 21st century France will be withdrawing from West Africa as she gets increasingly involved in the affairs [of Europe]. France's West African sphere of influence will be filled by Nigeria—a more natural hegemonic power. . . . It will be under those circumstances that Nigeria's own boundaries are likely to expand to incorporate the Republic of Niger (the Hausa link), the Republic of Benin (the Yoruba link) and conceivably Cameroon.

THE future could be more tumultuous, and bloodier, than Mazrui dares to say. France *will* withdraw from former colonies like Benin, Togo, Niger, and the Ivory Coast, where it has been propping up local currencies. It will do so not only because its attention will be diverted to new challenges in Europe and Russia but also because younger French officials lack the older generation's emotional ties to the ex-colonies. However, even as Nigeria attempts to expand, it, too, is likely to split into several pieces. The State Department's Bureau of Intelligence and Research recently made the following points in an analysis of Nigeria:

> Prospects for a transition to civilian rule and democratization are slim. . . . The repressive apparatus of the state security service . . . will be difficult for any future civilian government to control. . . . The country is becoming increasingly ungovernable. . . . Ethnic and regional splits are deepening, a situation made worse by an increase in the number of states from 19 to 30 and a doubling in the number of local governing authorities; religious cleavages are more serious; Muslim fundamentalism and evangelical Christian militancy are on the rise; and northern Muslim anxiety over southern [Christian] control of the economy is intense . . . the will to keep Nigeria together is now very weak.

Given that oil-rich Nigeria is a bellwether for the region—its population of roughly 90 million equals the populations of all the other West African states combined—it is apparent that Africa faces cataclysms that could make the Ethiopian and Somalian famines pale in comparison. This is especially so because Nigeria's population, including that of its largest city, Lagos, whose crime, pollution, and overcrowding make it the cliché par excellence of Third World urban dysfunction, is set to double during the next twenty-five years, while the country continues to deplete its natural resources.

Part of West Africa's quandary is that although its population belts are horizontal, with habitation densities increasing as one travels south away from the Sahara and toward the tropical abundance of the Atlantic littoral, the borders erected by European colonialists are vertical, and therefore at cross-purposes with demography and topography. Satellite photos depict the same reality I experienced in the bush taxi: the Lomé-Abidjan coastal corridor—indeed, the entire stretch of coast from Abidjan eastward to Lagos—is one burgeoning megalopolis that by any rational economic and geographical standard should constitute a single sovereignty, rather than the five (the Ivory Coast, Ghana, Togo, Benin, and Nigeria) into which it is currently divided.

As many internal African borders begin to crumble, a more impenetrable boundary is being erected that threatens to isolate the continent as a whole: the wall of disease. Merely to visit West Africa in some degree of safety, I spent about $500 for a hepatitis B vaccination series and other disease prophylaxis. Africa may today be more dangerous in this regard than it was in 1862, before antibiotics, when the explorer Sir Richard Francis Burton described the health situation on the continent as "deadly, a Golgotha, a Jehannum." Of the approximately 12 million people worldwide whose blood is HIV-positive, 8 million are in Africa. In the capital of the Ivory Coast, whose modern road system only

helps to spread the disease, 10 percent of the population is HIV-positive. And war and refugee movements help the virus break through to more-remote areas of Africa. Alan Greenberg, M.D., a representative of the Centers for Disease Control in Abidjan, explains that in Africa the HIV virus and tuberculosis are now "fast-forwarding each other." Of the approximately 4,000 newly diagnosed tuberculosis patients in Abidjan, 45 percent were also found to be HIV-positive. As African birth rates soar and slums proliferate, some experts worry that viral mutations and hybridizations might, just conceivably, result in a form of the AIDS virus that is easier to catch than the present strain.

It is malaria that is most responsible for the disease wall that threatens to separate Africa and other parts of the Third World from more-developed regions of the planet in the twenty-first century. Carried by mosquitoes, malaria, unlike AIDS, is easy to catch. Most people in sub-Saharan Africa have recurring bouts of the disease throughout their entire lives, and it is mutating into increasingly deadly forms. "The great gift of Malaria is utter apathy," wrote Sir Richard Burton, accurately portraying the situation in much of the Third World today. Visitors to malaria-afflicted parts of the planet are protected by a new drug, mefloquine, a side effect of which is vivid, even violent, dreams. But a strain of cerebral malaria resistant to mefloquine is now on the offensive. Consequently, defending oneself against malaria in Africa is becoming more and more like defending oneself against violent crime. You engage in "behavior modification": not going out at dusk, wearing mosquito repellent all the time.

IT IS MALARIA THAT IS MOST RESPONSIBLE FOR THE DISEASE WALL THAT THREATENS TO SEPARATE AFRICA AND OTHER PARTS OF THE THIRD WORLD FROM MORE-DEVELOPED REGIONS OF THE PLANET IN THE TWENTY-FIRST CENTURY. IT IS MUTATING INTO INCREASINGLY DEADLY FORMS.

And the cities keep growing. I got a general sense of the future while driving from the airport to downtown Conakry, the capital of Guinea. The forty-five-minute journey in heavy traffic was through one never-ending shantytown, a nightmarish Dickensian spectacle to which Dickens himself would never have given credence. The corrugated metal shacks and scabrous walls were coated with black slime. Stores were built out of rusted shipping containers, junked cars, and jumbles of wire mesh. The streets were one long puddle of floating garbage. Mosquitoes and flies were everywhere. Children, many of whom had protruding bellies, seemed as numerous as ants. When the tide went out, dead rats and the skeletons of cars were exposed on the mucky beach. In twenty-eight years Guinea's population will double if growth goes on at current rates. Hardwood logging continues at a madcap speed, and people flee the Guinean countryside for Conakry. It seemed to me that here, as elsewhere in Africa and the Third World, man is challenging nature far beyond its limits, and nature is now beginning to take its revenge.

AFRICA may be as relevant to the future character of world politics as the Balkans were a hundred years ago, prior to the two Balkan wars and the First World War. Then the threat was the collapse of empires and the birth of nations based solely on tribe. Now the threat is more elemental: *nature unchecked*. Africa's immediate future could be very bad. The coming upheaval, in which foreign embassies are shut down, states collapse, and contact with the outside world takes place through dangerous, disease-ridden coastal trading posts, will loom large in the century we are entering. (Nine of twenty-one U.S. foreign-aid missions to be closed over the next three years are in Africa—a prologue to a consolidation of U.S. embassies themselves.) Precisely because much of Africa is set to go over the edge at a time when the Cold War has ended, when environmental and demographic stress in other parts of the globe is becoming critical, and when the post–First World War system of nation-states—not just in the Balkans but perhaps also in the Middle East—is about to be toppled, Africa suggests what war, borders, and ethnic politics will be like a few decades hence.

To understand the events of the next fifty years, then, one must understand environmental scarcity, cultural and racial clash, geographic destiny, and the transformation of war. The order in which I have named these is not accidental. Each concept except the first relies partly on the one or ones before it, meaning that the last two—new approaches to mapmaking and to warfare—are the most important. They are also the least understood. I will now look at each idea, drawing upon the work of specialists and also my own travel experiences in various parts of the globe besides Africa, in order to fill in the blanks of a new political atlas.

THE ENVIRONMENT AS A HOSTILE POWER

FOR a while the media will continue to ascribe riots and other violent upheavals abroad mainly to ethnic and religious conflict. But as these conflicts multiply, it will become apparent that something else is afoot, making more and more places like Nigeria, India, and Brazil ungovernable.

Mention "the environment" or "diminishing natural resources" in foreign policy circles and you meet a brick wall of skepticism or boredom. To conservatives especially, the very terms seem flaky. Public-policy foundations have contributed to the lack of interest, by funding narrowly focused environmental studies replete with technical jargon which foreign-affairs experts just let pile up on their desks.

It is time to understand "the environment" for what it is: *the* national-security issue of the early twenty-first century. The political and strategic impact of surging populations, spreading disease, deforestation and soil erosion, water depletion, air pollution, and, possibly, rising sea levels in critical, overcrowded regions like the Nile Delta and Bangladesh—developments that will prompt mass migrations and, in turn, incite group conflicts—will be the core foreign-policy challenge from which most others will ultimately emanate, arousing the public and uniting assorted interests left over from the Cold War. In the twenty-first century water will be in dangerously short supply in such diverse locales as Saudi Arabia, Central Asia, and the southwestern United States. A war could erupt between Egypt and Ethiopia over Nile River water. Even in Europe tensions have arisen between Hungary and Slovakia over the damming of the Danube, a classic case of how environmental disputes fuse with ethnic and historical ones. The political scientist and erstwhile Clinton adviser Michael Mandelbaum has said, "We have a foreign policy today in the shape of a doughnut—lots of peripheral interests but nothing at the center." The environment, I will argue, is part of a terrifying array of problems that will define a new threat to our security, filling the hole in Mandelbaum's doughnut and allowing a post–Cold War foreign policy to emerge inexorably by need rather than by design.

OUR Cold War foreign policy truly began with George F. Kennan's famous article, signed "X," published in *Foreign Affairs* in July of 1947, in which Kennan argued for a "firm and vigilant containment" of a Soviet Union that was imperially, rather than ideologically, motivated. It may be that our post–Cold War foreign policy will one day be seen to have had its beginnings in an even bolder and more detailed piece of written analysis: one that appeared in the journal *International Security*. The article, published in the fall of 1991 by Thomas Fraser Homer-Dixon, who is the head of the Peace and Conflict Studies Program at the University of

Toronto, was titled "On the Threshold: Environmental Changes as Causes of Acute Conflict." Homer-Dixon has, more successfully than other analysts, integrated two hitherto separate fields—military-conflict studies and the study of the physical environment.

In Homer-Dixon's view, future wars and civil violence will often arise from scarcities of resources such as water, cropland, forests, and fish. Just as there will be environmentally driven wars and refugee flows, there will be environmentally induced praetorian regimes—or, as he puts it, "hard regimes." Countries with the highest probability of acquiring hard regimes, according to Homer-Dixon, are those that are threatened by a declining resource base yet also have "a history of state [read 'military'] strength." Candidates include Indonesia, Brazil, and, of course, Nigeria. Though each of these nations has exhibited democratizing tendencies of late, Homer-Dixon argues that such tendencies are likely to be superficial "epiphenomena" having nothing to do with long-term processes that include soaring populations and shrinking raw materials. Democracy is problematic; scarcity is more certain.

Indeed, the Saddam Husseins of the future will have more, not fewer, opportunities. In addition to engendering tribal strife, scarcer resources will place a great strain on many peoples who never had much of a democratic or institutional tradition to begin with. Over the next fifty years the earth's population will soar from 5.5 billion to more than nine billion. Though optimists have hopes for new resource technologies and free-market development in the global village, they fail to note that, as the National Academy of Sciences has pointed out, 95 percent of the population increase will be in the poorest regions of the world, where governments now—just look at Africa—show little ability to function, let alone to implement even marginal improvements. Homer-Dixon writes, ominously, "Neo-Malthusians may underestimate human adaptability in *today's* environmental-social system, but as time passes their analysis may become ever more compelling."

While a minority of the human population will be, as Francis Fukuyama would put it, sufficiently sheltered so as to enter a "post-historical" realm, living in cities and suburbs in which the environment has been mastered and ethnic animosities have been quelled by bourgeois prosperity, an increasingly large number of people will be stuck in history, living in shantytowns where attempts to rise above poverty, cultural dysfunction, and ethnic strife will be doomed by a lack of water to drink, soil to till, and space to survive in. In the developing world environmental stress will present people with a choice that is increasingly among totalitarianism (as in Iraq), fascist-tending mini-states (as in Serb-held Bosnia), and road-warrior cultures (as in Somalia). Homer-Dixon concludes that "as environmental degradation proceeds, the size of the potential social disruption will increase."

Left: El Playón, El Salvador, repository of garbage and death-squad victims. Right: Rio de Janeiro (top) and Shanghai, crowded and still growing.

Tad Homer-Dixon is an unlikely Jeremiah. Today a boyish thirty-seven, he grew up amid the sylvan majesty of Vancouver Island, attending private day schools. His speech is calm, perfectly even, and crisply enunciated. There is nothing in his background or manner that would indicate a bent toward pessimism. A Canadian Anglican who spends his summers canoeing on the lakes of northern Ontario, and who talks about the benign mountains, black bears, and Douglas firs of his youth, he is the opposite of the intellectually

MICHAEL NOL FOCUS/MATRIX. OPPOSITE: DONNA DICESARE/IMPACT VISUALS

CHIC GRAND/CONTACT

severe neoconservative, the kind at home with conflict scenarios. Nor is he an environmentalist who opposes development. "My father was a logger who thought about ecologically safe forestry before others," he says. "He logged, planted, logged, and planted. He got out of the business just as the issue was being polarized by environmentalists. They hate changed ecosystems. But human beings, just by carrying seeds around, change the natural world." As an only child whose playground was a virtually untouched wilderness and seacoast, Homer-Dixon has a familiarity with the natural world that permits him to see a reality that most pol-

icy analysts—children of suburbia and city streets—are blind to.

"We need to bring nature back in," he argues. "We have to stop separating politics from the physical world—the climate, public health, and the environment." Quoting Daniel Deudney, another pioneering expert on the security aspects of the environment, Homer-Dixon says that "for too long we've been prisoners of 'social-social' theory, which assumes there are only social causes for social and political changes, rather than natural causes, too. This social-social mentality emerged with the Industrial Revolution, which separated us from nature. But nature is coming back with a vengeance, tied to population growth. It will have incredible security implications.

"Think of a stretch limo in the potholed streets of New York City, where homeless beggars live. Inside the limo are the air-conditioned post-industrial regions of North America, Europe, the emerging Pacific Rim, and a few other isolated places, with their trade summitry and computer-information highways. Outside is the rest of mankind, going in a completely different direction."

WE are entering a bifurcated world. Part of the globe is inhabited by Hegel's and Fukuyama's Last Man, healthy, well fed, and pampered by technology. The other, larger, part is inhabited by Hobbes's First Man, condemned to a life that is "poor, nasty, brutish, and short." Although both parts will be threatened by environmental stress, the Last Man will be able to master it; the First Man will not.

The Last Man will adjust to the loss of underground water tables in the western United States. He will build dikes to save Cape Hatteras and the Chesapeake beaches from rising sea levels, even as the Maldive Islands, off the coast of India, sink into oblivion, and the shorelines of Egypt, Bangladesh, and Southeast Asia recede, driving tens of millions of people inland where there is no room for them, and thus sharpening ethnic divisions.

Homer-Dixon points to a world map of soil degradation in his Toronto office. "The darker the map color, the worse the degradation," he explains. The West African coast, the Middle East, the Indian subcontinent, China, and Central America have the darkest shades, signifying all manner of degradation, related to winds, chemicals, and water problems. "The worst degradation is generally where the population is highest. The population is generally highest where the soil is the best. So we're degrading earth's best soil."

China, in Homer-Dixon's view, is the quintessential example of environmental degradation. Its current economic "success" masks deeper problems. "China's fourteen percent growth rate does not mean it's going to be a world power. It means that coastal China, where the economic growth is taking place, is joining the rest of the Pacific Rim. The disparity with inland China is intensifying." Referring to the environmental research of his colleague, the Czech-born ecologist Vaclav Smil, Homer-Dixon explains how the per capita availability of arable land in interior China has rapidly declined at the same time that the quality of that land has been destroyed by deforestation, loss of topsoil, and salinization. He mentions the loss and contamination of water supplies, the exhaustion of wells, the plugging of irrigation systems and reservoirs with eroded silt, and a population of 1.54 billion by the year 2025: it is a misconception that China has gotten its population under control. Large-scale population movements are under way, from inland China to coastal China and from villages to cities, leading to a crime surge like the one in Africa and to growing regional disparities and conflicts in a land with a strong tradition of warlordism and a weak tradition of central government—again as in Africa. "We will probably see the center challenged and fractured, and China will not remain the same on the map," Homer-Dixon says.

Environmental scarcity will inflame existing hatreds and affect power relationships, at which we now look.

SKINHEAD COSSACKS, JUJU WARRIORS

IN the summer, 1993, issue of *Foreign Affairs*, Samuel P. Huntington, of Harvard's Olin Institute for Strategic Studies, published a thought-provoking article called "The Clash of Civilizations?" The world, he argues, has been moving during the course of this century from nation-state conflict to ideological conflict to, finally, cultural conflict. I would add that as refugee flows increase and as peasants continue migrating to cities around the world—turning them into sprawling villages—national borders will mean less, even as more power will fall into the hands of less educated, less sophisticated groups. In the eyes of these uneducated but newly empowered millions, the real borders are the most tangible and intractable ones: those of culture and tribe. Huntington writes, "First, differences among civilizations are not only real; they are basic," involving, among other things, history, language, and religion. "Second . . . interactions between peoples of different civilizations are increasing; these increasing interactions intensify civilization consciousness." Economic modernization is not necessarily a panacea, since it fuels individual and group ambitions while weakening traditional loyalties to the state. It is worth noting, for example, that it is precisely the wealthiest and fastest-developing city in India, Bombay, that has seen the worst intercommunal violence between Hindus and Muslims. Consider that Indian cities, like African and Chinese ones, are ecological time bombs—Delhi and Calcutta, and also Beijing, suffer the worst air quality of any cities in the world—and it is apparent how surging populations, environmental degradation, and ethnic conflict are deeply related.

Huntington points to interlocking conflicts among Hindu, Muslim, Slavic Orthodox, Western, Japanese, Confucian, Latin American, and possibly African civilizations: for instance, Hindus clashing with Muslims in India, Turkic Muslims clashing with Slavic Orthodox Russians in Central Asian cities, the West clashing with Asia. (Even in the United States, African-Americans find themselves besieged by an influx of competing Latinos.) Whatever the laws, refugees find a way to crash official borders, bringing their passions with them, meaning that Europe and the United States will be weakened by cultural disputes.

Because Huntington's brush is broad, his specifics are vulnerable to attack. In a rebuttal of Huntington's argument the Johns Hopkins professor Fouad Ajami, a Lebanese-born Shi'ite who certainly knows the world beyond suburbia, writes in the September-October, 1993, issue of *Foreign Affairs*,

> The world of Islam divides and subdivides. The battle lines in the Caucasus . . . are not coextensive with civilizational fault lines. The lines follow the interests of states. Where Huntington sees a civilizational duel between Armenia and Azerbaijan, the Iranian state has cast religious zeal . . . to the wind . . . in that battle the Iranians have tilted toward Christian Armenia.

True, Huntington's hypothesized war between Islam and Orthodox Christianity is not borne out by the alliance network in the Caucasus. But that is only because he has misidentified *which* cultural war is occurring there. A recent visit to Azerbaijan made clear to me that Azeri Turks, the world's most secular Shi'ite Muslims, see their cultural identity in terms not of religion but of their Turkic race. The Armenians, likewise, fight the Azeris not because the latter are Muslims but because they are Turks, related to the same Turks who massacred Armenians in 1915. Turkic culture (secular and based on languages employing a Latin script) is battling Iranian culture (religiously militant as defined by Tehran, and wedded to an Arabic script) across the whole swath of Central Asia and the Caucasus. The Armenians are, therefore, natural allies of their fellow Indo-Europeans the Iranians.

Huntington is correct that the Caucasus is a flashpoint of cultural and racial war. But, as Ajami observes, Huntington's plate tectonics are too simple. Two months of recent travel throughout Turkey revealed to me that although the Turks are developing a deep distrust, bordering on hatred, of fellow-Muslim Iran, they are also, especially in the shantytowns that are coming to dominate Turkish public opinion, revising their group identity, increasingly seeing themselves as Muslims being deserted by a West that does little to help besieged Muslims in Bosnia and that attacks Turkish Muslims in the streets of Germany.

In Bosnia, the former Yugoslavia, campatriots add one more victim of civil war to a mass grave

In other words, the Balkans, a powder keg for nation-state war at the beginning of the twentieth century, could

CHRISTOPHER MORRIS/BLACK STAR

be a powder keg for cultural war at the turn of the twenty-first: between Orthodox Christianity (represented by the Serbs and a classic Byzantine configuration of Greeks, Russians, and Romanians) and the House of Islam. Yet in the Caucasus that House of Islam is falling into a clash between Turkic and Iranian civilizations. Ajami asserts that this very subdivision, not to mention all the divisions within the Arab world, indicates that the West, including the United States, is not threatened by Huntington's scenario. As the Gulf War demonstrated, the West has proved capable of playing one part of the House of Islam against another.

True. However, whether he is aware of it or not, Ajami is describing a world even more dangerous than the one Huntington envisions, especially when one takes into account Homer-Dixon's research on environmental scarcity. Outside the stretch limo would be a rundown, crowded planet of skinhead Cossacks and *jujo* warriors, influenced by the worst refuse of Western pop culture and ancient tribal hatreds, and battling over scraps of overused earth in guerrilla

conflicts that ripple across continents and intersect in no discernible pattern—meaning there's no easy-to-define threat. Kennan's world of one adversary seems as distant as the world of Herodotus.

Most people believe that the political earth since 1989 has undergone immense change. But it is minor compared with what is yet to come. The breaking apart and remaking of the atlas is only now beginning. The crack-up of the Soviet empire and the coming end of Arab-Israeli military confrontation are merely prologues to the really big changes that lie ahead. Michael Vlahos, a long-range thinker for the U.S. Navy, warns, "We are not in charge of the environment and the world is not following us. It is going in many directions. Do not assume that democratic capitalism is the last word in human social evolution."

Before addressing the questions of maps and of warfare, I want to take a closer look at the interaction of religion, culture, demographic shifts, and the distribution of natural resources in a specific area of the world: the Middle East.

THE PAST IS DEAD

BUILT on steep, muddy hills, the shantytowns of Ankara, the Turkish capital, exude visual drama. Altindag, or "Golden Mountain," is a pyramid of dreams, fashioned from cinder blocks and corrugated iron, rising as though each shack were built on top of another, all reaching awkwardly and painfully toward heaven—the heaven of wealthier Turks who live elsewhere in the city. Nowhere else on the planet have I found such a poignant architectural symbol of man's striving, with gaps in house walls plugged with rusted cans, and leeks and onions growing on verandas assembled from planks of rotting wood. For reasons that I will explain, the Turkish shacktown is a psychological universe away from the African one.

To see the twenty-first century truly, one's eyes must learn a different set of aesthetics. One must reject the overly stylized images of travel magazines, with their inviting photographs of exotic villages and glamorous downtowns. There are far too many millions whose dreams are more vulgar, more real—whose raw energies and desires will overwhelm the visions of the elites, remaking the future into something frighteningly new. But in Turkey I learned that shantytowns are not all bad.

Slum quarters in Abidjan terrify and repel the outsider. In Turkey it is the opposite. The closer I got to Golden Mountain the better it looked, and the safer I felt. I had $1,500 worth of Turkish lira in one pocket and $1,000 in traveler's checks in the other, yet I felt no fear. Golden Mountain was a real neighborhood. The inside of one house told the story: The architectural bedlam of cinder block and sheet metal and cardboard walls was deceiving. Inside was a *home*—order, that is, bespeaking dignity. I saw a working refrigerator, a television, a wall cabinet with a few books and lots of family pictures, a few plants by a window, and a stove. Though the streets become rivers of mud when it rains, the floors inside this house were spotless.

Other houses were like this too. Schoolchildren ran along with briefcases strapped to their backs, trucks delivered cooking gas, a few men sat inside a café sipping tea. One man sipped beer. Alcohol is easy to obtain in Turkey, a secular state where 99 percent of the population is Muslim. Yet there is little problem of alcoholism. Crime against persons is infinitesimal. Poverty and illiteracy are watered-down versions of what obtains in Algeria and Egypt (to say nothing of West Africa), making it that much harder for religious extremists to gain a foothold.

My point in bringing up a rather wholesome, crime-free slum is this: its existence demonstrates how formidable is the fabric of which Turkish Muslim culture is made. A culture this strong has the potential to dominate the Middle East once again. Slums are litmus tests for innate cultural strengths and weaknesses. Those peoples whose cultures can harbor extensive slum life without decomposing will be, relatively speak-

SADDAM HUSSEINS OF THE FUTURE WILL HAVE MORE, NOT FEWER, OPPORTUNITIES. IN ADDITION TO ENGENDERING TRIBAL STRIFE, SCARCER RESOURCES WILL PLACE A GREAT STRAIN ON MANY PEOPLES WHO NEVER HAD MUCH OF A DEMOCRATIC OR INSTITUTIONAL TRADITION TO BEGIN WITH.

ing, the future's winners. Those whose cultures cannot will be the future's victims. Slums—in the sociological sense—do not exist in Turkish cities. The mortar between people and family groups is stronger here than in Africa. Resurgent Islam and Turkic cultural identity have produced a civilization with natural muscle tone. Turks, history's perennial nomads, take disruption in stride.

The future of the Middle East is quietly being written inside the heads of Golden Mountain's inhabitants. Think of an Ottoman military encampment on the eve of the destruction of Greek Constantinople in 1453. That is Golden Mountain. "We brought the village here. But in the village we worked harder—in the field, all day. So we couldn't fast during [the holy month of] Ramadan. Here we fast. Here we are more religious." Aishe Tanrikulu, along with half a dozen other women, was stuffing rice into vine leaves from a crude plastic bowl. She asked me to join her under the shade of a piece of sheet metal. Each of these women had her hair covered by a kerchief. In the city they were encountering television for the first time. "We are traditional, religious people. The programs offend us," Aishe said. Another woman complained about the schools. Though her children had educational options unavailable in the village, they had to compete with wealthier, secular Turks. "The kids from rich families with connections—they get all the places." More opportunities, more tensions, in other words.

My guidebook to Golden Mountain was an untypical one: *Tales From the Garbage Hills*, a brutally realistic novel by a Turkish writer, Latife Tekin, about life in the shantytowns, which in Turkey are called *gecekondus* ("built in a night"). "He listened to the earth and wept unceasingly for water, for work and for the cure of the illnesses spread by the garbage and the factory waste," Tekin writes. In the most revealing passage of *Tales From the Garbage Hills* the squatters are told "about a certain 'Ottoman Empire' . . . that where they now lived there had once been an empire of this name." This history "confounded" the squatters. It was the first they had heard of it. Though one of them knew "that his grandfather and his dog died fighting the Greeks," nationalism and an encompassing sense of Turkish history are the province of the Turkish middle and upper classes, and of foreigners like me who feel required to have a notion of "Turkey."

But what did the Golden Mountain squatters know about the armies of Turkish migrants that had come before their own—namely, Seljuks and Ottomans? For these recently urbanized peasants, and their counterparts in Africa, the Arab world, India, and so many other places, the world is new, to adapt V. S. Naipaul's phrase. As Naipaul wrote of urban refugees in *India: A Wounded Civilization*, "They saw themselves at the beginning of things: unaccommodated men making a claim on their land for the first time, and out of chaos evolving their own philosophy of community and self-help. For them the past was dead; they had left it behind in the villages."

Everywhere in the developing world at the turn of the twenty-first century these new men and women, rushing into the cities, are remaking civilizations and redefining their identities in terms of religion and tribal ethnicity which do not coincide with the borders of existing states.

IN Turkey several things are happening at once. In 1980, 44 percent of Turks lived in cities; in 1990 it was 61 percent. By the year 2000 the figure is expected to be 67 percent. Villages are emptying out as concentric rings of *gecekondu* developments grow around Turkish cities. This is the real political and demographic revolution in Turkey and elsewhere, and foreign correspondents usually don't write about it.

Whereas rural poverty is age-old and almost a "normal" part of the social fabric, urban poverty is socially destabilizing. As Iran has shown, Islamic extremism is the psychological defense mechanism of many urbanized peasants threatened with the loss of traditions in pseudo-modern cities where their values are under attack, where basic services like water and electricity are unavailable, and where they are assaulted by a physically unhealthy environment. The American ethnologist and orientalist Carleton Stevens Coon wrote in 1951 that Islam "has made possible the optimum survival and happiness of millions of human beings in an increasingly impoverished environment over a fourteen-hundred-year period." Beyond its stark, clearly articulated message, Islam's very militancy makes it attractive to the downtrodden. It is the one religion that is prepared to *fight*. A political era driven by environmental stress, increased cultural sensitivity, unregulated urbanization, and refugee migrations is an era divinely created for the spread and intensification of Islam, already the world's fastest-growing religion. (Though Islam is spreading in West Africa, it is being hobbled by syncretization with animism; this makes new converts less apt to become anti-Western extremists, but it also makes for a weakened version of the faith, which is less effective as an antidote to crime.)

In Turkey, however, Islam is painfully and awkwardly forging a consensus with modernization, a trend that is less apparent in the Arab and Persian worlds (and virtually invisible in Africa). In Iran the oil boom—because it put development and urbanization on a fast track, making the culture shock more intense—fueled the 1978 Islamic Revolution. But Turkey, unlike Iran and the Arab world, has little oil. Therefore its development and urbanization have been more gradual. Islamists have been integrated into the parliamentary system for decades. The tensions I noticed in Golden Mountain are natural, creative ones: the kind immigrants face the world

THIS PAGE AND OPPOSITE: ARI KATZ/IMPACT VISUALS

over. While the world has focused on religious perversity in Algeria, a nation rich in natural gas, and in Egypt, parts of whose capital city, Cairo, evince worse crowding than I have seen even in Calcutta, Turkey has been living through the Muslim equivalent of the Protestant Reformation.

Resource distribution is strengthening Turks in another way vis-à-vis Arabs and Persians. Turks may have little oil, but their Anatolian heartland has lots of water—the most important fluid of the twenty-first century. Turkey's Southeast Anatolia Project, involving twenty-two major dams and irrigation systems, is impounding the waters of the Tigris and Euphrates rivers. Much of the water that Arabs and perhaps Israelis will need to drink in the future is controlled by Turks. The project's centerpiece is the mile-wide, sixteen-story Atatürk Dam, upon which are emblazoned the words of modern Turkey's founder: "*Ne Mutlu Turkum Diyene*" ("Lucky is the one who is a Turk")

Unlike Egypt's Aswan High Dam, on the Nile, and Syria's Revolution Dam, on the Euphrates, both of which were built largely by Russians, the Atatürk Dam is a predominantly Turkish affair, with Turkish engineers and companies in charge. On a recent visit my eyes took in the immaculate offices and their gardens, the high-voltage electric grids and phone switching stations, the dizzying sweep of giant humming transformers, the poured-concrete spillways, and the prim unfolding suburbia, complete with schools, for dam employees. The emerging power of the Turks was palpable.

Erduhan Bayindir, the site manager at the dam, told me that "while oil can be shipped abroad to enrich only elites, water has to be spread more evenly within the society. . . . It is true, we can stop the flow of water into Syria and Iraq for up to eight months without the same water overflowing our dams, in order to regulate their political behavior."

Power is certainly moving north in the Middle East, from the oil fields of Dhahran, on the Persian Gulf, to the water plain of Harran, in southern Anatolia—near the site of the Atatürk Dam. But will the nation-state of Turkey, as presently constituted, be the inheritor of this wealth?

I very much doubt it.

THE LIES OF MAPMAKERS

WHEREAS West Africa represents the least stable part of political reality outside Homer-Dixon's stretch limo, Turkey, an organic outgrowth of two Turkish empires that ruled Anatolia for 850 years, has been among the most stable. Turkey's borders were established not by colonial powers but in a war of independence, in the early 1920s. Kemal Atatürk provided Turkey with a secular nation-building myth that most Arab and African states, burdened by artificially drawn borders, lack. That lack will leave many Arab states defenseless against a wave of Islam that will eat away at their legitimacy and frontiers in coming years. Yet even as regards Turkey, maps deceive.

It is not only African shantytowns that don't appear on urban maps. Many shantytowns in Turkey and elsewhere are also missing—as are the considerable territories controlled by guerrilla armies and urban mafias. Traveling with Eritrean guerrillas in what, according to the map, was northern Ethiopia, traveling in "northern Iraq" with Kurdish guerrillas, and staying in a hotel in the Caucasus controlled

Opposite page: Kurds in Turkey defy the government by kindling ritual fires. Above: a Kurdish guerrilla fighter; Kurdish children with spent shells.

by a local mafia—to say nothing of my experiences in West Africa—led me to develop a healthy skepticism toward maps, which, I began to realize, create a conceptual barrier that prevents us from comprehending the political crack-up just beginning to occur worldwide.

Consider the map of the world, with its 190 or so countries, each signified by a bold and uniform color: this map, with which all of us have grown up, is generally an invention of modernism, specifically of European colonialism. Modernism, in the sense of which I speak, began with the rise of nation-states in Europe and was confirmed by the death of feudalism at the end of the Thirty Years' War—an event that was interposed between the Renaissance and the Enlightenment, which together gave birth to modern science. People were suddenly flush with an enthusiasm to categorize, to define. The map, based on scientific techniques of measurement, offered a way to classify new national organisms, making a jigsaw puzzle of neat pieces without transition zones between them. "Frontier" is itself a modern concept that didn't exist in the feudal mind. And as European nations carved out far-flung domains at the same time that print technology was making the reproduction of maps cheaper, cartography came into its own as a way of creating facts by ordering the way we look at the world.

In his book *Imagined Communities: Reflections on the Origin and Spread of Nationalism*, Benedict Anderson, of Cornell University, demonstrates that the map enabled colonialists to think about their holdings in terms of a "totalizing classificatory grid . . . It was bounded, determinate, and therefore—in principle—countable." To the colonialist, country maps were the equivalent of an accountant's ledger books. Maps, Anderson explains, "shaped the grammar" that would make possible such questionable concepts as Iraq, Indonesia, Sierra Leone, and Nigeria. The state, recall, is a purely Western notion, one that until the twentieth century applied to countries covering only three percent of the earth's land area. Nor is the evidence compelling that the state, as a governing ideal, can be successfully transported to areas outside the industrialized world. Even the United States of America, in the words of one of our best living poets, Gary Snyder, consists of "arbitrary and inaccurate impositions on what is really here."

Yet this inflexible, artificial reality staggers on, not only in the United Nations but in various geographic and travel publications (themselves by-products of an age of elite touring

which colonialism made possible) that still report on and photograph the world according to "country." Newspapers, this magazine, and this writer are not innocent of the tendency.

According to the map, the great hydropower complex emblemized by the Atatürk Dam is situated in Turkey. Forget the map. This southeastern region of Turkey is populated almost completely by Kurds. About half of the world's 20 million Kurds live in "Turkey." The Kurds are predominant in an ellipse of territory that overlaps not only with Turkey but also with Iraq, Iran, Syria, and the former Soviet Union. The Western-enforced Kurdish enclave in northern Iraq, a consequence of the 1991 Gulf War, has already exposed the fictitious nature of that supposed nation-state.

On a recent visit to the Turkish-Iranian border, it occurred to me what a risky idea the nation-state is. Here I was on the legal fault line between two clashing civilizations, Turkic and Iranian. Yet the reality was more subtle: as in West Africa, the border was porous and smuggling abounded, but here the people doing the smuggling, on both sides of the border, were Kurds. In such a moonscape, over which peoples have migrated and settled in patterns that obliterate borders, the end of the Cold War will bring on a cruel process of natural selection among existing states. No longer will these states be so firmly propped up by the West or the Soviet Union. Because the Kurds overlap with nearly everybody in the Middle East, on account of their being cheated out of a state in the post–First World War peace treaties, they are emerging, in effect, as *the* natural selector—the ultimate reality check. They have destabilized Iraq and may continue to disrupt states that do not offer them adequate breathing space, while strengthening states that do.

THE SAVAGERY OF THE FIGHTING POINTS TO A TRUTH THAT WE LACK THE STOMACH TO CONTEMPLATE: A LARGE NUMBER OF PEOPLE ON THIS PLANET, TO WHOM THE COMFORT AND STABILITY OF A MIDDLE-CLASS LIFE IS UTTERLY UNKNOWN, FIND WAR AND A BARRACKS EXISTENCE A STEP UP.

Because the Turks, owing to their water resources, their growing economy, and the social cohesion evinced by the most crime-free slums I have encountered, are on the verge of big-power status, and because the 10 million Kurds within Turkey threaten that status, the outcome of the Turkish-Kurdish dispute will be more critical to the future of the Middle East than the eventual outcome of the recent Israeli-Palestinian agreement.

AMERICA'S fascination with the Israeli-Palestinian issue, coupled with its lack of interest in the Turkish-Kurdish one, is a function of its own domestic and ethnic obsessions, not of the cartographic reality that is about to transform the Middle East. The diplomatic process involving Israelis and Palestinians will, I believe, have little effect on the early- and mid-twenty-first-century map of the region. Israel, with a 6.6 percent economic growth rate based increasingly on high-tech exports, is about to enter Homer-Dixon's stretch limo, fortified by a well-defined political community that is an organic outgrowth of history and ethnicity. Like prosperous and peaceful Japan on the one hand, and war-torn and poverty-wracked Armenia on the other, Israel is a classic national-ethnic organism. Much of the Arab world, however, will undergo alteration, as Islam spreads across artificial frontiers, fueled by mass migrations into the cities and a soaring birth rate of more than 3.2 percent. Seventy percent of the Arab population has been born since 1970—youths with little historical memory of anticolonial independence struggles, postcolonial attempts at nation-building, or any of the Arab-Israeli wars. The most distant recollection of these youths will be the West's humiliation of colonially invented Iraq in 1991. Today seventeen out of twenty-two Arab states have a declining gross national product; in the next twenty years, at current growth rates, the population of many Arab countries will double. These states, like most African ones, will be ungovernable through conventional secular ideologies. The Middle East analyst Christine M. Helms explains,

> Declaring Arab nationalism "bankrupt," the political "disinherited" are not rationalizing the failure of Arabism . . . or reformulating it. Alternative solutions are not contemplated. They have simply opted for the political paradigm at the other end of the political spectrum with which they are familiar—Islam.

Like the borders of West Africa, the colonial borders of Syria, Iraq, Jordan, Algeria, and other Arab states are often contrary to cultural and political reality. As state control mechanisms wither in the face of environmental and demographic stress, "hard" Islamic city-states or shantytown-states are likely to emerge. The fiction that the impoverished city of Algiers, on the Mediterranean, controls Tamanrasset, deep in the Algerian Sahara, cannot obtain forever. Whatever the outcome of the peace process, Israel is destined to be a Jewish ethnic fortress amid a vast and volatile realm of Islam. In that realm, the violent youth culture of the Gaza shantytowns may be indicative of the coming era.

The destiny of Turks and Kurds is far less certain, but far more relevant to the kind of map that will explain our future world. The Kurds suggest a geographic reality that cannot be shown in two-dimensional space. The issue in Turkey is not simply a matter of giving autonomy or even independence to

PATRICK ROBERT/SYGMA

Kurds in the southeast. This isn't the Balkans or the Caucasus, where regions are merely subdividing into smaller units, Abkhazia breaking off from Georgia, and so on. Federalism is not the answer. Kurds are found everywhere in Turkey, including the shanty districts of Istanbul and Ankara. Turkey's problem is that its Anatolian land mass is the home of two cultures and languages, Turkish and Kurdish. Identity in Turkey, as in India, Africa, and elsewhere, is more complex and subtle than conventional cartography can display.

A NEW KIND OF WAR

To appreciate fully the political and cartographic implications of postmodernism—an epoch of themeless juxtapositions, in which the classificatory grid of nation-states is going to be replaced by a jagged-glass pattern of city-states, shanty-states, nebulous and anarchic regionalisms—it is necessary to consider, finally, the whole question of war.

"Oh, what a relief to fight, to fight enemies who defend themselves, enemies who are awake!" André Malraux wrote in *Man's Fate*. I cannot think of a more suitable battle cry for many combatants in the early decades of the twenty-first century. The intense savagery of the fighting in such diverse cultural settings as Liberia, Bosnia, the Caucasus, and Sri Lanka—to say nothing of what obtains in American inner cities—indicates something very troubling that those of us inside the stretch limo, concerned with issues like middle-class entitlements and the future of interactive cable television, lack the stomach to contemplate. It is this: a large number of people on this planet, to whom the comfort and stability of a middle-class life is utterly unknown, find war and a barracks existence a step up rather than a step down.

"Just as it makes no sense to ask 'why people eat' or 'what they sleep for,'" writes Martin van Creveld, a military historian at the Hebrew University in Jerusalem, in *The Transformation of War*, "so fighting in many ways is not a means but an end. Throughout history, for every person who has expressed his horror of war there is another who found in it the most marvelous of all the experiences that are vouchsafed to man, even to the point that he later spent a lifetime boring his descendants by recounting his exploits." When I asked Pentagon officials about the nature of war in the twenty-first century, the answer I frequently got was "Read Van Creveld." The top brass are enamored of this historian not because his writings justify their existence but, rather, the opposite: Van Creveld warns them that huge state military machines like the Pentagon's are dinosaurs about to go extinct, and that something far more terrible awaits us.

The degree to which Van Creveld's *Transformation of War* complements Homer-Dixon's work on the environment, Huntington's thoughts on cultural clash, my own realizations in traveling by foot, bus, and bush taxi in more than sixty countries, and America's sobering comeuppances in intractable-culture zones like Haiti and Somalia is startling. The book begins by demolishing the notion that men don't like to fight. "By compelling the senses to focus themselves on the here and now," Van Creveld writes, war "can cause a man to take his leave of them." As anybody who has had experience with Chetniks in Serbia, "technicals" in Somalia, Tontons Macoutes in Haiti, or soldiers in Sierra Leone can tell you, in places where the Western Enlightenment has not penetrated and where there has always been mass poverty, people find liberation in violence. In Afghanistan and elsewhere, I vicariously experienced this phenomenon: worrying about mines and ambushes frees you from worrying about mundane details of daily existence. If my own experience is too subjective, there is a wealth of data showing the sheer frequency of war, especially in the developing world since the Second World War. Physical aggression is a part

In Liberia, summary justice meted out against a soldier (above) and suspected thieves (below right). Above right: a scene in Vukovar, the former Yugoslavia.

of being human. Only when people attain a certain economic, educational, and cultural standard is this trait tranquilized. In light of the fact that 95 percent of the earth's population growth will be in the poorest areas of the globe, the question is not whether there will be war (there will be a lot of it) but what kind of war. And who will fight whom?

Debunking the great military strategist Carl von Clausewitz, Van Creveld, who may be the most original thinker on war since that early-nineteenth-century Prussian, writes, "Clausewitz's ideas . . . were wholly rooted in the fact that, ever since 1648, war had been waged overwhelmingly by states." But, as Van Creveld explains, the period of nation-states and, therefore, of state conflict is now ending, and with it the clear "threefold division into government, army, and people" which state-directed wars enforce. Thus, to see the future, the first step is to look back to the past immediately prior to the birth of modernism—the wars in medieval Europe which began during the Reformation and reached their culmination in the Thirty Years' War.

Van Creveld writes,

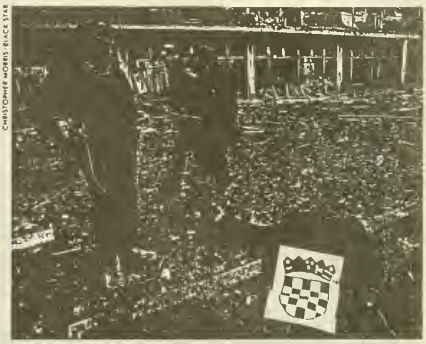
> In all these struggles political, social, economic, and religious motives were hopelessly entangled. Since this was an age when armies consisted of mercenaries, all were also attended by swarms of military entrepreneurs. . . . Many of them paid little but lip service to the organizations for whom they had contracted to fight. Instead, they robbed the countryside on their own behalf. . .
>
> Given such conditions, any fine distinctions . . between armies on the one hand and peoples on the other were bound to break down. Engulfed by war, civilians suffered terrible atrocities.

BACK then, in other words, there was no "politics" as we have come to understand the term, just as there is less and less "politics" today in Liberia, Sierra Leone, Somalia, Sri Lanka, the Balkans, and the Caucasus, among other places.

Because, as Van Creveld notes, the radius of trust within tribal societies is narrowed to one's immediate family and guerrilla comrades, truces arranged with one Bosnian commander, say, may be broken immediately by another Bosnian commander. The plethora of short-lived ceasefires in the Balkans and the Caucasus constitute proof that we are no longer in a world where the old rules of state warfare apply. More evidence is provided by the destruction of medieval monuments in the Croatian port of Dubrovnik: when cultures, rather than states, fight, then cultural and religious monuments are weapons of war, making them fair game.

Also, war-making entities will no longer be restricted to a specific territory. Loose and shadowy organisms such as Islamic terrorist organizations suggest why borders will mean increasingly little and sedimentary layers of tribalistic identity and control will mean more. "From the vantage point of the present, there appears every prospect that religious . . . fanaticisms will play a larger role in the motivation of armed conflict" in the West than at any time "for the last 300 years," Van Creveld writes. This is why analysts like Michael Vlahos are closely monitoring religious cults. Vlahos says, "An ideology that challenges us may not take familiar form, like the old Nazis or Commies. It may not even engage us initially in ways that fit old threat markings." Van Creveld concludes, "Armed conflict will be waged by men on earth, not robots in space. It will have more in common with the struggles of primitive tribes than with large-scale conventional war." While another military historian, John Keegan, in his new book *A History of Warfare*, draws a more benign portrait of primitive man, it is important to point out that what Van Creveld really means is *re-primitivized* man: warrior societies operating at a time of unprecedented resource scarcity and planetary overcrowding.

Van Creveld's pre-Westphalian vision of worldwide low-intensity conflict is not a superficial "back to the future" scenario. First of all, technology will be used toward primitive ends. In Liberia the guerrilla leader Prince Johnson didn't



CHRISTOPHER MORRIS, BLACK STAR

PATRICK ROBERTS/SIGMA

just cut off the ears of President Samuel Doe before Doe was tortured to death in 1990—Johnson made a video of it, which has circulated throughout West Africa. In December of 1992, when plotters of a failed coup against the Strasser regime in Sierra Leone had their ears cut off at Freetown's Hamilton Beach prior to being killed, it was seen by many to be a copycat execution. Considering, as I've explained earlier, that the Strasser regime is not really a government and that Sierra Leone is not really a nation-state, listen closely to Van Creveld: "Once the legal monopoly of armed force, long claimed by the state, is wrested out of its hands, existing distinctions between war and crime will break down much as is already the case today in . . . Lebanon, Sri Lanka, El Salvador, Peru, or Colombia."

If crime and war become indistinguishable, then "national defense" may in the future be viewed as a local concept. As crime continues to grow in our cities and the ability of state governments and criminal-justice systems to protect their citizens diminishes, urban crime may, according to Van Creveld, "develop into low-intensity conflict by coalescing along racial, religious, social, and political lines." As small-scale violence multiplies at home and abroad, state armies will contime to shrink, being gradually replaced by a booming private security business, as in West Africa, and by urban mafias especially in the former communist world, who may be better equipped than municipal police forces to grant physical protection to local inhabitants.

Future wars will be those of communal survival, aggravated or, in many cases, caused by environmental scarcity. These wars will be subnational, meaning that it will be hard for states and local governments to protect their own citizens physically. This is how many states will ultimately die. As state power fades—and with it the state's ability to help weaker groups within society, not to mention other states—peoples and cultures around the world will be thrown back upon their own strengths and weaknesses, with fewer equalizing mechanisms to protect them. Whereas the distant future will probably see the emergence of a racially hybrid, globalized man, the coming decades will see us more aware of our differences than of our similarities. To the average person, political values will mean less, personal security more. The belief that we are all equal is liable to be replaced by the overriding obsession of the ancient Greek travelers: Why the differences between peoples?

ESSER/CHAN WOODIN/Corbis

THE LAST MAP

In *Geography and the Human Spirit*, Anne Buttimer, a professor at University College, Dublin, recalls the work of an early-nineteenth-century German geographer, Carl Ritter, whose work implied "a divine plan for humanity" based on regionalism and a constant, living flow of forms. The map of the future, to the extent that a map is even possible, will represent a perverse twisting of Ritter's vision. Imagine cartography in three dimensions, as if in a hologram. In this hologram would be the overlapping sediments of group and other identities atop the merely two-dimensional color markings of city-states and the remaining nations, themselves confused in places by shadowy tentacles, hovering overhead, indicating the power of drug cartels, mafias, and private security agencies. Instead of borders, there would be moving "centers" of power, as in the Middle Ages. Many of these layers would be in motion. Replacing fixed and abrupt lines on a flat space would be a shifting pattern of buffer entities, like the Kurdish and Azeri buffer entities between Turkey and Iran, the Turkic Uighur buffer entity between Central Asia and Inner China (itself distinct from coastal China), and the Latino buffer entity replacing a precise U.S.-Mexican border. To this protean cartographic hologram one must add other factors, such as migrations of populations, explosions of birth rates, vectors of disease. Henceforward the map of the world will never be static. This future map—in a sense, the "Last Map"—will be an ever-mutating representation of chaos.

The Indian subcontinent offers examples of what is happening. For different reasons, both India and Pakistan are increasingly dysfunctional. The argument over democracy in these places is less and less relevant to the larger issue of governability. In India's case the question arises, Is one unwieldy bureaucracy in New Delhi the best available mechanism for promoting the lives of 866 million people of diverse languages, religions, and ethnic groups? In 1950, when the Indian population was much less than half as large and nation-building idealism was still strong, the argument for democracy was more impressive than it is now. Given that in 2025 India's population could be close to 1.5 billion, that much of its economy rests on a shrinking natural-resource base, including dramatically declining water levels, and that communal violence and urbanization are spiraling upward, it is difficult to imagine that the Indian state will survive the next century. India's oft-trumpeted Green Revolution has been achieved by overworking its croplands and depleting its watershed. Norman Myers, a British development consultant, worries that Indians have "been feeding themselves today by borrowing against their children's food sources."

Pakistan's problem is more basic still: like much of Africa, the country makes no geographic or demographic sense. It was founded as a homeland for the Muslims of the subcontinent, yet there are more subcontinental Muslims outside Pakistan than within it. Like Yugoslavia, Pakistan is a patchwork of ethnic groups, increasingly in violent conflict with one another. While the Western media gushes over the fact that the country has a woman Prime Minister, Benazir Bhutto, Karachi is becoming a subcontinental version of Lagos. In eight visits to Pakistan, I have never gotten a sense of a cohesive national identity. With as much as 65 percent of its land dependent on intensive irrigation, with wide-scale deforestation, and with a yearly population growth of 2.7 percent (which ensures that the amount of cultivated land per rural inhabitant will plummet), Pakistan is becoming a more and more desperate place. As irrigation in the Indus River basin intensifies to serve two growing populations, Muslim-Hindu strife over falling water tables may be unavoidable.

Arson and looting in Los Angeles after the acquittal of police officers in the Rodney King case

"India and Pakistan will probably fall apart," Homer-Dixon predicts. "Their secular governments have less and less legitimacy as well as less management ability over people and resources." Rather than one bold line dividing the subcontinent into two parts, the future will likely see a lot of thinner lines and smaller parts, with the ethnic entities of Pakhtunistan and Punjab gradually replacing Pakistan in the space between the Central Asian plateau and the heart of the subcontinent.

None of this even takes into account climatic change, which, if it occurs in the next century, will further erode the capacity of existing states to cope. India, for instance, receives 70 percent of its precipitation from the monsoon cycle, which planetary warming could disrupt.

Not only will the three-dimensional aspects of the Last Map be in constant motion, but its two-dimensional base may change too. The National Academy of Sciences reports that

> as many as one billion people, or 20 per cent of the world's population, live on lands likely to be inundated or dramatically changed by rising waters. . . . Low-lying countries in the developing world such as Egypt and Bangladesh, where rivers are large and the deltas extensive and densely populated, will be hardest hit. . . . Where the rivers are dammed, as in the case of the Nile, the effects . . . will be especially severe.

Egypt could be where climatic upheaval—to say nothing of the more immediate threat of increasing population—will incite religious upheaval in truly biblical fashion. Natural catastrophes, such as the October, 1992, Cairo earthquake, in which the government failed to deliver relief aid and slum residents were in many instances helped by their local mosques, can only strengthen the position of Islamic factions. In a statement about greenhouse warming which could refer to any of a variety of natural catastrophes, the environmental expert Jessica Tuchman Matthews warns that many of us underestimate the extent to which political systems, in affluent societies as well as in places like Egypt, "depend on the underpinning of natural systems." She adds, "The fact that one can move with ease from Vermont to Miami has nothing to say about the consequences of Vermont acquiring Miami's climate."

Indeed, it is not clear that the United States will survive the next century in exactly its present form. Because America is a multi-ethnic society, the nation-state has always been more fragile here than it is in more homogeneous societies like Germany and Japan. James Kurth, in an article published in *The National Interest* in 1992, explains that whereas nation-state societies tend to be built around a mass-conscription army and a standardized public school system, "multicultural regimes" feature a high-tech, all-volunteer army (and, I would add, private schools that teach competing values), operating in a culture in which the international media and entertainment industry has more influence than the "national political class." In other words, a nation-state is a place where everyone has been educated along similar lines, where people take their cue from national leaders, and where everyone (every male, at least) has gone through the crucible of military service, making patriotism a simpler issue. Writing about his immigrant family in turn-of-the-century Chicago, Saul Bellow states, "The country took us over. It *was* a country then, not a collection of 'cultures.'"

During the Second World War and the decade following it, the United States reached its apogee as a classic nation-state. During the 1960s, as is now clear, America began a slow but unmistakable process of transformation. The signs hardly need belaboring: racial polarity, educational dysfunction, social fragmentation of many and various kinds. William Irwin Thompson, in *Passages About Earth: An Exploration of the New Planetary Culture*, writes, "The educational system that had worked on the Jews or the Irish could no longer work on the blacks; and when Jewish teachers in New York tried to take black children away from their parents exactly in the way they had been taken from theirs, they were shocked to encounter a violent affirmation of negritude."

Issues like West Africa could yet emerge as a new kind of foreign-policy issue, further eroding America's domestic peace. The spectacle of several West African nations collapsing at once could reinforce the worst racial stereotypes here at home. That is another reason why Africa matters. We must not kid ourselves: the sensitivity factor is higher than ever. The Washington, D.C., public school system is already experimenting with an Afrocentric curriculum. Summits between African leaders and prominent African-Americans are becoming frequent, as are Pollyanna-ish prognostications about multiparty elections in Africa that do not factor in crime, surging birth rates, and resource depletion. The Congressional Black Caucus was among those urging U.S. involvement in Somalia and in Haiti. At the *Los Angeles Times* minority staffers have protested against, among other things, what they allege to be the racist tone of the newspaper's Africa coverage, allegations that the editor of the "World Report" section, Dan Fisher, denies, saying essentially that Africa should be viewed through the same rigorous analytical lens as other parts of the world.

Africa may be marginal in terms of conventional late-twentieth-century conceptions of strategy, but in an age of cultural and racial clash, when national defense is increasingly local, Africa's distress will exert a destabilizing influence on the United States.

This and many other factors will make the United States less of a nation than it is today, even as it gains territory following the peaceful dissolution of Canada. Quebec, based on the bedrock of Roman Catholicism and Francophone ethnicity, could yet turn out to be North America's most cohesive and crime-free nation-state. (It may be a smaller Quebec, though, since aboriginal peoples may lop off northern parts of the province.) "Patriotism" will become increasingly regional as people in Alberta and Montana discover that they have far more in common with each other than they do with Ottawa or Washington, and Spanish-speakers in the Southwest discover a greater commonality with Mexico City. (*The Nine Nations of North America*, by Joel Garreau, a book about the continent's regionalization, is more relevant now than when it was published, in 1981.) As Washington's influence wanes, and with it the traditional symbols of American patriotism, North Americans will take psychological refuge in their insulated communities and cultures.

RETURNING from West Africa last fall was an illuminating ordeal. After leaving Abidjan, my Air Afrique flight landed in Dakar, Senegal, where all passengers had to disembark in order to go through another security check, this one demanded by U.S. authorities before they would permit the flight to set out for New York. Once we were in New York, despite the midnight hour, immigration officials at Kennedy Airport held up disembarkation by conducting quick interrogations of the aircraft's passengers—this was in addition to all the normal immigration and customs procedures. It was apparent that drug smuggling, disease, and other factors had contributed to the toughest security procedures I have ever encountered when returning from overseas.

Then, for the first time in over a month, I spotted businesspeople with attaché cases and laptop computers. When I had left New York for Abidjan, all the businesspeople were boarding planes for Seoul and Tokyo, which departed from gates near Air Afrique's. The only non-Africans off to West Africa had been relief workers in T-shirts and khakis. Although the borders within West Africa are increasingly unreal, those separating West Africa from the outside world are in various ways becoming more impenetrable.

But Afrocentrists are right in one respect: we ignore this dying region at our own risk. When the Berlin Wall was falling, in November of 1989, I happened to be in Kosovo, covering a riot between Serbs and Albanians. The future was in Kosovo, I told myself that night, not in Berlin. The same day that Yitzhak Rabin and Yasser Arafat clasped hands on the White House lawn, my Air Afrique plane was approaching Bamako, Mali, revealing corrugated-zinc shacks at the edge of an expanding desert. The real news wasn't at the White House, I realized. It was right below.

THE COMING ANARCHY

Mr. BROWN. "The Coming Anarchy." And he begins in West Africa, and points out that the combination of population growth and environmental degradation are just driving people across borders, into cities, on a scale without precedent. And he says that the instability from this, the social disintegration, is going to reduce things to a clan and tribal and religious sort of set of conflicts over land and resources, access to water—which we have not talked about at all—on a scale that is going to create a future quite different than anything that we have seen or imagined.

It is interesting because he is a political analyst, essentially. He is a well-established writer. And he is not from the environmental movement by any stretch of the imagination.

But what I think we are going to discover is that these disruptions are going to begin to affect the functioning of the economy and the ability of national political and economic leaders to sustain progress as we have known it.

You mentioned the 10 billion people by 2040. That is the standard projection. I personally do not think we are ever going to get close to it. I think well before we get there—keep in mind that the next 5 billion are coming almost entirely in developing countries——

Senator BUMPERS. I have made that statement 100 times in speeches.

Mr. BROWN. Yes.

Senator BUMPERS. We will not get to 10 billion because we cannot.

Mr. BROWN. No.

Systems will start breaking down. First, the ecosystems, and then, the economic systems that depend on them.

So, I think we are faced with an extraordinarily challenging situation, and one where, if we do not take the initiative and begin to intervene, and if the United States does not provide leadership, I doubt that the world is going to get the leadership needed to begin reversing some of these trends before they begin to feed on themselves.

Senator BUMPERS. Did you know that in Italy, which should be commended by every thoughtful person in the world, because Italy actually has a declining population, they ought to be beating their chests and patting themselves on the back—and yet, there is a real concern now among Italians that Italians may become extinct. I mean, if you think about how foolish that is, to think in those terms. And yet, if you go to Italy today, you hear people, demographers, actually talk about people genuinely concerned about the survival of their ethnicity.

But, in any event, just one question, and then I will defer to Senator Cochran. You have recommended, the Worldwatch Institute, Sandra Postel, is that her name?

Mr. BROWN. Yes, Sandra Postel.

Senator BUMPERS. Has recommended, for example—if the price of meat derived from grain-fed livestock included the soil erosion, depletion of water supplies and other environmental damage done in the process of production, meat intake would fall, freeing up

more grain for direct consumption. While I can understand generally why that is a good thought, how on earth would you devise such a tax?

Mr. BROWN. There is an emerging school of thought, even among some economists now—and I think Sandra is reflecting that—that the existing economic system does not tell the truth. The market does not tell the truth, because the people who are burning coal, for example, do not pay the costs of the health problems from breathing polluted air, for example; or the cost of forest destruction in Europe from coal-burning powerplants.

And there is a growing move to say that we should have a full-cost accounting system, and everything should pay its own way. And that is, in a sense, the argument she is making. And just as we have made the same argument for automobiles, where they fill cities and create congestion and create air pollution, because we have not thought through very rationally how to design a transportation system that provides mobility without damaging people's health, for example.

So, I would not for a minute disagree with Sandra's point, but the larger point that that is directed toward is the question of distribution of food in the world. And I think it has been about 25 years ago that I made the calculation that if all the grain in the world were equitably distributed, there would be no hunger or malnutrition. That is still true today. But the diet would not be a very varied diet.

And I would like to draw your attention to the table on page 191, to give some sense of what this translates into. I picked four countries in this table, the United States, which used about 800 kilograms of grain per year; Italy, 400; China, 300; and India, 200. I then looked at the livestock consumption patterns in those countries. What you see is that the United States consumes a lot of all the livestock products, except mutton; Italy consumes quite a bit of everything in almost the same proportions, but substantially less; China does not consume too much of anything except pork. Their pork consumption is essentially at the industrial country level.

Now, what this means, interestingly, and I did not realize this until I was doing this table some months ago, is that China is now the world's largest consumer of red meat. In the United States, per capita consumption is still higher, because we consume both pork and even larger quantities of beef per person. But, because of the numbers in China, they are now the world's largest consumer of red meat.

In India, they do not consume much of anything except eggs. They consume as much eggs, basically, as those of us living in industrial countries.

The point I want to make is that the minute incomes start to go up, one of the first things people do is try to diversify their diet—get away from a diet where 70 percent of the calories comes from rice or corn or wheat or what have you, and get some livestock products in it, and then, some fruit and vegetables. Everyone in the world wants to move up and get more protein.

Now, that is a reality. I know of no country that has said, you know, we are not going to move up that grain requirements ladder.

Senator BUMPERS. Let me interrupt you just a moment there, because I am not a scientist and I do not understand this. We talk about beef, for example, especially, as being heavy protein. What about the grain that cow consumes; is that not protein too? Is it not just converted into beef?

Mr. BROWN. It is protein that is concentrated into beef in a rather inefficient manner. If we are looking at the basic livestock products, in the feedlot, it takes about 7 pounds of grain to get an additional pound of beef.

Senator BUMPERS. That is what I want to ask you. We get 1 pound of beef for each 7 pounds of wheat, grain or corn, for example, that we produce?

Mr. BROWN. Yes.

Senator BUMPERS. Well, go ahead. I have a question when you finish. I interrupted you.

Mr. BROWN. OK. And with pork, it is about 4 pounds of grain per pound of pork. For poultry, it is about 2. So, poultry has a real advantage. And, indeed, poultry production is rising much faster worldwide.

Senator BUMPERS. Do not talk about poultry now; we are big in that, too.

Mr. BROWN. Poultry production is rising much more rapidly than pork or beef, and we will probably overtake world beef production before the end of this decade. So, it is moving very fast.

But the point I wanted to make is everyone wants a better diet everywhere in the world. Now, some of us may go a little bit too far. I think I would say that most of us would be a bit healthier and better off if we consumed a bit less in the way of livestock products. But the reality is that food is distributed in the world today through the market. And the only exception to that is food aid. The international food aid program is about 10 million tons of wheat—of grain—maybe 11 million tons. But even if we doubled that, that would only feed 55 million people at the Indian level of consumption. And that is 7 months of world population growth. It is not very much.

So, it seems to me that the idea of redistributing the world's food supply is not a very realistic one, partly because we have not been able to find any society that has voluntarily moved down this grain requirements ladder. The United Kingdom did in World War II, when the U-boats cut off their grain supply. And that has become a classic study in heart disease epidemiology, because their level of heart disease dropped substantially during that period.

In this country, after the doubling of grain prices in 1972, our use of grain for livestock dropped rather sharply—probably 15 to 20 percent. But then it started coming back up again and resumed the trend.

The Russians, more recently, have reduced their consumption of livestock products rather substantially. But in none of these cases was it voluntarily. It was in response to economic or other forces that forced the reduction.

So, while it is nice to be able to say, if all the grain in the world were equitably distributed no one would be hungry, I think the reality is that it is not likely to happen, at least on a very large scale.

Senator BUMPERS. Mr. Brown, one final question dealing with rice. You stated that world rice production was about as high right now as it could get—something to that effect—that there is very little land left in which to raise rice.

Mr. BROWN. Let me clarify that before we go further.

Two things: One, the production of rice is unique among the grains in that it is constrained both by the supply of land and the supply of fresh water. Second, rice yields in the higher-yielding countries, like Japan, appear to be plateauing and have been for about a decade now, even with very strong economic incentives. So, that probably represents, with any existing technologies, the upper limit to what we can expect of other countries.

That is not the same as saying that we cannot increase rice production in the world somewhat more, though the increases are becoming much more difficult now to realize.

Senator BUMPERS. Let me make a couple of comments. No. 1, while we are the biggest rice producer in the country, I think we probably produce between 40 and 45 percent of all the rice produced in America, I can tell you that we are facing water problems right now, and we are struggling to sustain the kind of acreage that we have always had in rice production. No. 2, this past year, we had a mediocre crop, because we had more disease than we have had in the past.

But while we could probably expand at least temporarily our rice production, we only represent, in America, not in Arkansas but in America, we only represent 2 percent of the world's rice production. I do not want rice prices to go down because our farmers are really benefiting from this rapid escalation of rice prices in the last 6 months. But the truth of the matter is, when you consider that Japan is going to import 2 million tons, that is just a blip in the world's rice production and can probably be accommodated without too much difficulty.

But the other side of the coin is I think we have probably about reached what you say is the maximum. But, in all fairness, I remember when I became governor in 1971, we considered 90 to 100 bushels per acre to be a very good crop. And, as you know, 20 years later, it is not at all uncommon to make 200 bushels per acre.

We have increased the amount of fertilizer we use, and we have increased the strains. You know, we have all kinds of hybrids. I think there are roughly 1,000 different kinds of rice in China. It is an unbelievable thing.

But the only point I want to make is there are people who think that we can continue to improve these strains genetically, and that this is not ever going to be a problem. I think that is really hiding your head in the sand. I do not care how long the problem is off, it is coming. And the time to deal with it is now. But there is just no enthusiasm for it, as I pointed out earlier.

Senator Cochran.

Senator COCHRAN. Thank you very much, Mr. Chairman.

I find the hearing to be very interesting. And I am very glad to see that you have included as witnesses those who have views that differ somewhat from Dr. Brown's. I noticed, in reading Dennis Avery's statement, for example, he has a different view about some of these matters than Lester Brown. The other witnesses have

points of view that are important for us to consider as well as we undertake to try to understand this subject, so we can make policy decisions that are based upon good information and data and facts. Rather than rumor and some of the hysterical arguments that we might hear from time to time on these subjects, it is good for us to hear a wide-ranging discussion on the issues.

In connection with the statement of Mr. Brown, I am interested in a few of the observations from the point of view of taking the other side just for the purpose of questioning you on it. The suggestion, for example, that we might use the tax policy of countries like the United States to tax the consumption of beef or meat products in order to reduce the level of consumption as a way of dealing with this problem to me is rather curious in that we have seen a substantial reduction and decline in consumption of those products because people have decided on their own that they would prefer other alternatives; that they may be healthier if they consume more fish or more poultry or more vegetables and less beef.

Is this not maybe a matter of educational challenge as much as it is tax policy change that we are looking to help us through this situation?

Mr. BROWN. There are actually two issues here. One is the question of what is good for us, and knowing what that is. I mean, we used to think that—I can remember high school football teams used to have a big steak before a football game because it was thought that by eating a lot of, you know, really rare steak, that was the thing to do. But we do not think that any more. It is a much more sophisticated approach.

And it seems to me that we are learning more and more about the relationship between diet and health. And I think most of the authorities, whether it is NIH or the National Academy, would all point out that consuming a lot of fat-rich livestock products is just not the healthiest thing for most of us to do, and that we would be healthier if we consumed somewhat less, and more fruits and vegetables and a more diverse diet overall. That is a matter of education, largely.

There is another issue, and that is the fact that a lot of the costs associated with things that we do economically are not paid by those who are producing the products—whether it is generating electricity with high sulfur coal and creating all kinds of health problems in the communities, the utility does not pay that; the individuals have to pay that health care bill.

And what Sandra was arguing for, and I think quite properly, is that we need an honest accounting system, one that tells the truth. And the market, the way we operate it, does not tell the truth.

Senator COCHRAN. So, are you still suggesting that we can avert a future worldwide grain shortage by taxing the consumption of meat products? Is that not one of your suggestions?

Mr. BROWN. No; I do not think we can. I think it would obviously help some, but the point I was making with this distribution table is that everyone in the world wants to move up. And when you get 1.2 billion Chinese doing that, it puts an enormous pressure on resources, and eventually on resources outside their own country. And so, I think I am saying that we have got to look at the population question much more carefully than we have in the past, and

to recognize that—the question is now probably not whether population growth is going to start slowing fairly rapidly, but whether it slows because the world moves rapidly toward smaller families or because hunger and malnutrition increase and death rates begin to rise, often tangled up with political instability and civil war and ethnic conflicts and other things that are fed by a deteriorating situation.

Senator COCHRAN. I do not get your response to my question about using taxation as a way of enlarging the supplies of grain for the rest of the world. Are you saying that you have not made that recommendation or you now are not making that recommendation?

Mr. BROWN. No; I am trying to separate the points. One is what is good for us healthwise and how we improve our health by adjusting our diet. I think the important thing there is public education, as with the cigarette smoking example. Many people have changed their behavior in response to information.

It also happens that if you increase the tax on cigarettes you discourage people from smoking. And that would also happen with fat-rich livestock products. If the full cost of a piece of very fat beef that has been in the feedlot for a while were actually reflected in that, the overpumping of the aquifer that produces the feedstuffs, the soil erosion, the use of some of the pesticides that we were discussing earlier—if the costs of those, the indirect costs are included, which is what I think we should use the tax for, then that would have the effect of moving us down the——

Senator COCHRAN. I see. I appreciate your explaining that for me.

One other area that I find difficult to comprehend is the suggestion that we are at the end of the road in developing technologies or making scientific advances that increase food supply or improve our ability to feed the world. And I think immediately of the advances that we are seeing in Arkansas and in Mississippi in the development of the aquaculture industries there—fish production—a lot of that has come about just in the last few years as a matter of fact.

The catfish industry in our State, for example, I think has led the way, in many respects, in this area. But there are others, as well, and it is not just that species. But fish farming generally has become quite a new advancement in the development of an alternative protein that is available now.

I think of the Tilapia fish that now is being looked at as a possible new source of protein in warm water areas, and the tremendous production capability that has been discovered recently—the bovine implant, the ability to improve pork production with less grain and having a leaner meat product—all because of scientific advances just in the last few years. To some extent, you have production agriculture really resisting in the United States the availability of these new scientific discoveries because it may overproduce the market and depress prices to farmers.

And so, it seems to me that here you are saying we should not do any more or depend too much on science in the future, and I think the evidence is overwhelmingly on the other side of that.

Mr. BROWN. Actually, what I said was I think we should be investing far more in agricultural research in the years ahead than

we have been in the past and, on the entire front of agriculture, I think we need to be investing more. One of the difficulties is that the need for food is often not in the form of effective demand. So, per capita, food consumption in most of Africa has been declining now for more than a decade

I think technology can play a role, and deserves to be invested in more heavily, not less so.

What I did say is that I do not now see—I pointed out that all the major technologies we have been using for the last four decades were available before that period began.

Senator COCHRAN. Yes; you mentioned that in 1847 they discovered the chemical reintroduction of minerals in the soil would help replenish those that were taken out by the growing plants.

Mr. BROWN. Right.

Senator COCHRAN. And you mentioned another one in the 1860's, as if they were the greatest inventions that had ever been made.

Mr. BROWN. Right, that was the 1860's, when Mendel——

Senator COCHRAN. But we are seeing more and more things that are being developed now that are making tremendous contributions in our ability to produce quantities of food at cheaper prices.

Mr. BROWN. Right. What I did say is that—what I also said was I do not see any technologies in prospect or in the pipeline that can lead to the quantum jumps in output of the sort that we got from the enormous growth in fertilizer we were looking at earlier, or the hybridization of corn.

I think there will be advances, but I do not see grain yields tripling again over the next four decades, for example, as they have over the last four decades. And I cite Japan as evidence of a country that is having great difficulty getting any increases in rice yields now, and for the last 10 years.

So, I think we need to be investing in research and, in particular, in refining research for local application. Because we have been using kind of a general formula, and very successfully, over the last four decades of more fertilizer and higher yielding varieties and more water. We now know that more water is going to be difficult to come by in large areas of the world. And so, we are going to have to devise locally sophisticated technologies for raising production—a little bit here and a little bit there—and it takes a lot more research to do that. When you can have one centralized technology that blankets the world, it is really very efficient.

Senator COCHRAN. Thank you very much.

Senator BUMPERS. Mr. Brown, thank you very much. I just close on one comment along the lines that Senator Cochran is talking about. This subcommittee is charged with responsibility of appropriating money for agricultural research. I can tell you that we have and will continue to appropriate hundreds of millions of dollars for agricultural research. The real purpose of this hearing is to point up that we have to approach this in a two-pronged way.

Obviously, there can be some progress made in increased production. Research will produce some hybrids and some difference in strains that will give us more. But, ultimately, the train wreck will occur, because that, in itself, will not solve the problem. It is going to take that and population control, both, in my opinion.

Thank you very much for being with us.

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Mr. BROWN. My pleasure.

Senator BUMPERS. Our next witness is Dennis Avery, senior fellow of the Hudson Institute; director, Center for Global Food Issues. Mr. Avery formerly served as a senior agricultural analyst in the U.S. Department of State from 1980 to 1988. He is an internationally known expert on the dynamic changes taking place in the world's ability to feed itself and still protect environmental resources. He is especially noted for his analyses of trends in food demand, agricultural productivity, and global farm competition.

He is the principal author of "Global Food Progress," and his forthcoming book, "Saving the Planet with Pesticides and Plastic: The Environmental Triumph of High Yield Farming," will claim environmental credit for high-yield farming: for the millions of square miles of wildlife habitat not plowed for food, the soil erosion not endured because we concentrated production on the safest acres, and the cancers not caused because we chemically suppress the molds and toxins and offered ample supplies of low-cost chemically grown fruits and vegetables.

Welcome, Mr. Avery, and please proceed.

HUDSON INSTITUTE

STATEMENT OF DENNIS AVERY, SENIOR FELLOW AND DIRECTOR, CENTER FOR GLOBAL FOOD ISSUES

Mr. AVERY. Thank you very much, Senator. And I would like to commend the panel for inviting me.

It is a pleasure finally to be on the platform with Les Brown and to answer his food and famine misrepresentations directly on the record. I hope that by the end of my testimony you, Senator Bumpers, and possibly even Lester Brown, will be somewhat more hopeful about the outlook, because we will underscore the reality that there are, indeed, two strings to the boat.

I will say this is the first time since 1974 I am aware Lester Brown has recommended additional funding for agricultural research, although he still does not seem to have much hope for it.

Given the focus today already on rice, let me depart from my written presentation and open with a little vignette of what agricultural research apparently will be able to do based on what we can already see. And this is from a personal visit to the International Rice Research Institute in Los Banos, the Philippines in 1993.

The Institute believes that it can raise world rice yields by 50 to 75 percent by the year 2030. They believe they can do this, first of all, by hybridizing rice—and Chinese hybrids have shown that this yields a 25- to 30-percent gain in rice production per acre.

In addition, they are redesigning the rice plant to put 10 percent more of its energy into the grain head, and supporting that with fewer but larger tillers in the plant. They then plan to use genetic engineering techniques to take resistance to the white-backed plant hopper from the barley plant, insert it in rice; take resistance to the yellow stem borer from another plant, add it to the rice plant; take resistance or tolerance to salt stress from halophyte plants, and add those to the rice plant.

It is a dramatic demonstration. And since Mr. Brown is worried about running out of productivity from hybrid corn—it is a dramatic demonstration of the latest, new, big frontier in agricultural research that is indeed biotechnology.

I will agree with Mr. Brown and endorse his concern that we do indeed have a very large food challenge before us. In fact, I do not think it is an overestimate to say that in the next 40 to 50 years the world will have to triple the output of its farms and ranches. My concern, however, is not so much famine. I have no doubt that the world's human population will find ways to feed themselves and preserve the lives of their children. The question is whether we will do this by turning high-yield agriculture into higher yield agriculture, or whether we will do it by eliminating most of the world's wildlife habitat.

There is, indeed, apparently a fundamental human hunger for high-quality protein, Senator Bumpers. Most of the vegetable protein sources that are available to us—I think all of them, in fact—are deficient in at least one of the major amino acids. And this seems to produce this human hunger for high-quality protein.

The real question in my view is whether we can indeed triple world food output while saving our wildlife habitat, without encroaching on forests and reducing the global soil erosion losses, rather than accepting the current wildly predicted increase in soil erosion.

I would like to emphasize that I do not believe population growth, in itself, is a direct threat to wildlife. People currently occupy 1.4 percent of the Earth's land surface. A redoubled human population is estimated to take only about 3.5 percent of the land area. If those people live on a small amount of land, treat their sewage, and use clean energy sources, that offers no threat to wildlife or the environment.

The key potential threat to wildlife obviously lies in the need to produce food and forest products. Agriculture, of course, already occupies one-third of the world's surface, and its yields could well determine whether forests can continue to occupy the one-third of the Earth's land surface they have now. I think it is absolutely certain that the most critical decisions we make for the quality of life in the 21st century will be on agriculture.

I would also like to emphasize that we will not be able to choose between people and wildlife. The environmental movement has taken to implying that wildlife is so important we can put wild creatures ahead of humans. But, regardless of how they feel, it is clear that we cannot let the people starve and still save the wildlife, because the Third World will not be able to hire enough game wardens to protect the elephants and gorillas if the people are truly hungry.

The people will be fed unless they have already destroyed all of the wildlife habitat in their last desperate efforts to save their children.

That means higher food productivity is fully as important to wildlife and conservation as it is to the people. The food challenge of the 21st century is to triple food output on the land that is already in agriculture, instead of by expanding cropland.

We are fortunate—all of the serious recent studies of world food production potential have reached the same conclusion: the world should be able to feed a human population larger than the one we have, and in fact, larger than the one we project when we reach zero population growth in the middle of the next century. It will not be easy. It will not be without cost. It is, however, doable.

If we continue the current trends of progress in plant breeding, pest control, irrigation engineering, and improved farming systems, we should be able to provide caloric sufficiency for 9 million to 12 billion people without clearing more forests or plowing more wildlife. It is encouraging to note that the Third World countries have recently been raising their food production by 3.9 percent per year—nearly double their population growth rate.

Per capita calories in the developing countries have risen 27 percent since 1962, and rose 6 percent in the 1980's. Actual dietary gains have been even more important, because diets recently have included far more cooking oil, more meat, milk, eggs, fruits, and vegetables.

As an example, China's fruit and vegetable consumption has risen 80 percent in the past 5 years.

The first payoff from biotechnology will apparently be rice plants that are resistant to the rice tungro virus. These varieties can apparently save 7 million tons of rice production per year.

Bovine somatatropin can raise dairy feed efficiency by 10 percent. Pork somatatropin will apparently let us produce hogs with one-third less fat, using 25 percent less feed grain. Biotechnology is also allowing us, through cloning and tissue culture, to raise per-acre yields in tree and forest crops by fourfold to sixfold.

Contrary to some misleading reports, there has been no slowdown in Third World food production gains since 1984. The slowing in world food production has been in the First World, where governments in the United States, Japan, and the European Community have been attempting to prevent their farmers from raising yields and production further, because of the surplus cost involved.

Total food production in the developing countries, 1984 to 1991, rose 3.8 percent annually; population growth rate, 2.1 percent. A decade earlier, in 1975 to 1981, developing country cereal production rose at 2.8 percent annually, but total food production rose only 2.86 percent; population growth averaged 2.3 percent.

Clearly, the poor countries' rate of grain in total food production per capita has been even higher in the past decade, than the rapid gains in the 1970's. Total food production in the 1975 to 1981 period outstripped population growth by 24 percent. Total food production in the 1984 to 1991 period outstripped population growth by 81 percent. Some crisis.

There are two major policy initiatives the Hudson Institute believes are critically needed, if we are to meet the enormous challenge of food in the 21st century. Unfortunately, the environmental movement is opposing both of those policy initiatives.

We, first of all, must make substantial further investments in high-yield farming technology, so that we can produce still more farm products from each acre we use in agriculture. Second, we must liberalize trade in farm products, so we can use the best and safest acres to meet the challenge.

Asia will be eight or nine times as densely populated per acre of farmland as the Western Hemisphere. It is unfortunate that the environmental movement seems to want to solve the food problem only if it can be solved by suppressing human population growth, and limiting human diet.

And unfortunately for the environment of the world, population management cannot come strongly or swiftly enough to preclude the need for higher farm output. We will get zero population growth, but we will not get it until after we have needed three times more farm output.

Organic farming cannot save the world or its wildlife. Organic farming yields are one-half or less of the yields on the world's best mainstream farms. Worse, the world has perhaps only 80 percent, or, only 20 percent, of the organic—that is a typo in my testimony; it should be 20 percent, not 80 percent—20 percent of the organic nitrogen needed to support current farm output, let alone the huge increase in production that will be needed by 2050.

Furthermore, organic farming cannot cost-effectively provide the year-round abundance and variety of fruits and vegetables needed to protect people from cancer and heart disease.

Now that the threat of nuclear war with the Soviet Union has receded, organic farming may, in fact, represent the greatest single threat to humanity and the wildlife on this planet.

The best news on the population front, in fact, is not population management, which begins to take effect only after people have begun to become more affluent; it is that hundreds of millions of poor people are beginning to get rich faster than any group of people has ever done so in the past.

The major reason is the General Agreement on Tariffs and Trade, which is spreading access to wealth, access to markets around the world. GATT is the reason why today China is the world's hottest market for jetliners; and McDonald's has decided to enter the fast-food market in Hindu, India.

Because of freer trade, the world has a fighting chance to restabilize its population at 9 billion people, rather than 12 billion.

By demanding population suppression instead of agricultural research and trade, people like Lester Brown and Paul Ehrlich are playing Russian roulette with the world's wildlife.

Far from being kind and gentle humanists, they represent a harsh elitism. They seem to want a sparsely populated world, even if it takes the world's biggest famines and history's largest wildlife losses to get it.

There is nothing wrong with supporting population management; but there is a great deal wrong with demanding population management instead of research on higher yield farming.

As we speak, the U.S. Agency for International Development is cutting its agricultural research support, and shifting the funds toward population programs. And yet, the jewel in the crown of international aid is the Green Revolution. It was brought about through the international agricultural research centers.

Twenty-five percent of the funding for those centers has and does come from USAID; and those centers have not only produced the Green Revolution. They have produced high yield in casaba for Africa; hybrid sorghum for Africa; bananas and plantains that resist

the dreaded Black Sigatoka disease which threatened to destroy one of the Third World's most important food crops.

They are producing high-protein corn, to relieve the severe protein deficiencies in poor corn-eating countries. They have the design for the miracle rice of the 21st century. They are not sure they will have the funding to carry forward the project.

And these centers are also pioneering soil-saving farming systems for the Third World, including alley cropping and tied ridges.

No foreign aid program, no program supported by the First World, has ever come close to matching the enormous success of agricultural research for people, and for the environment.

I do not understand why the environmental movement is not demanding more high-yield farming research with all the fervor of the ACT–UP organization, demanding more AIDS research funding. I do not understand why the environmental organizations are not cheering on the farmers who safely produce more food per acre, instead of throwing roadblocks in their path.

I do not understand why the environmental activists are not picketing Capitol Hill, demanding free trade in farm products, instead of objecting to it.

If we ignore, if we do not fully fund, the potential of further agricultural research for higher yields, we risk plowing down 25 to 40 million square miles of wildlife habitat on this planet if, in fact, that much land can take a plow point.

I would point out that, in fact, we have now produced a—research has produced—a farming system based on kudzu, that could actually sustain itself in the Amazon; which means we must produce ag productivity somewhere else, if we are not to see the rain forest plowed down to meet people's food needs.

And we are in danger of ignoring or rejecting soil conservation farming systems that have cut soil erosion to the lowest levels in 10,000 years.

Mr. Brown has recently credited a U.S. farm bill for cutting soil erosion in this country by one-third in recent years. It was not a farm bill, it was herbicides.

To his credit, Mr. Brown in 1974 recommended both population management and agricultural research. Since his anointment by the environmental movement, however, he has loudly and consistently told us that agricultural research cannot do us any good; and he told us again today, not to expect much from it.

He has fraudulently claimed that the recent food production gains have come from mining soil and ground water, instead of from plant breeding, animal and poultry genetics and fertilizer. He has not only disregarded the enormous gains from plant breeding, but announced that agricultural technology could not solve the world food problem since it has not bred a higher yielding soybean.

The soybean is about the only plant where we have not achieved marvelous yield gains.

He has misrepresented world food production statistics, in a vain attempt to cover up the most dramatic gains in world food security ever made; and has deliberately—apparently, deliberately—obfuscated the contribution of agricultural and farmer incentives in achieving those gains.

He has claimed the world would run out of fresh water for farming, when agricultural and irrigation engineering can readily triple the efficiency of its water use.

Let us go forward from this hearing with a new resolve to protect both the world's people and its wildlife, because we have no other real choice. Let us go forward with a renewed pride in our research institutions and the knowledge they have produced. Let us go forward with thanks to the activists who have stimulated environmental preservation.

But let us go forward, with both support for agricultural research and population management to the fullest reasonable extent, based on their revealed capacities to resolve food, population, wildlife, and land use conflicts.

Realistically, that means a far higher priority on agricultural research and farm trade than our current Federal policies have accorded. Thank you.

PREPARED STATEMENT

Senator BUMPERS. Thank you, Mr. Avery, for your testimony. We have your complete statement and it will be made part of the record.

[The statement follows:]

STATEMENT OF DENNIS T. AVERY

Humanity's age-old concern about food security has been heightened in recent decades by: (1) the continuing growth in world population; (2) our increasing concern for preserving environmental quality and natural resources; and (3) worries that the Green Revolution in farm productivity has come to an end.

Recently, environmental writers such as Lester Brown and Paul Ehrlich have even renewed their claims that the world is headed for massive famine.

In reality, the world faces a bigger food challenge than even the environmental movement has realized.

THE 21ST CENTURY FOOD CHALLENGE

We must not only feed twice as many people in the 21st century, but we must also feed them better.

—Poor people have poor diets and large families. Affluent people have small families, but they demand to eat well. Thus, food production plays an important positive role in restabilizing the world population.

—We are finding what is apparently a fundamental human hunger for the high-quality protein found in cooking oil, meat, milk, and eggs. There is no historic evidence of any country or culture ever having voluntarily adopted a vegetarian diet. Nor are any countries or cultures doing so now. China's meat consumption is currently rising at more than 3 million tons per year. India's milk consumption is expanding by 2 million tons annually. Indonesia's poultry market is expanding at double-digit rates.

—There is an urgent global health need for more fruits and vegetables—humanity's strongest weapons against cancer and heart disease. These fruit and vegetable crops cannot currently be produced in abundance through organic methods.

—More affluent people want more cotton for clothing, especially when the economic progress occurs in the tropics.

—All of these farm commodities are resource-intensive. It takes twice as many farming resources to produce a calorie of cooking oil as a calorie of cereals. Poultry and eggs take 3–4 times the resources per calorie as cereals. Pork takes 5–6 times as many resources per unit. Fruits, vegetables and cotton require extra pest control efforts because they are so attractive to insects, diseases and fungi.

Thus, the world food challenge means not only feeding twice as many people, but feeding them a more resource-costly diet.

Summing up these demands, the world will have to roughly triple the output of its agriculture over the next 40 years or so.

ADDING ENVIRONMENTAL RESOURCE DEMAND

Even this huge challenge leaves out another critical element of demand—the environment.

We live in the first human generation which does not consider plowing a virgin prairie or clearing a forest for crops as a triumph of the human spirit. We have suddenly come to the point where we value preservation of environmental resources nearly as much as our own well-being.

The final and critical element of the 21st century food challenge is environmental.

—Can we preserve our quality of life and enhance the environment while we triple world food output?

—Will we be able to save our wildlife habitat?

—Can we avoid encroaching on forests?

—Will we have to pollute critical water resources to eat well?

—Can we achieve a reduction in global soil erosion losses, rather than the current widely-predicted increase?

POPULATION GROWTH IS NOT THE REAL THREAT TO WILDLIFE

It is clear that simply having more people needn't threaten the planet's wildlife. Every naturalist agrees that habitat is the key to preserving wild organisms.

People currently occupy only 1.4 percent of the earth's land surface. A redoubled human population is estimated to take only about 3.5 of the land area—virtually none of it in the rain forest.

If 10 billion people live on 3.5 percent of the land, treat their sewage and use clean energy sources, that offers no threat to wildlife or the environment.

The key potential threat to wildlife obviously lies in the need to produce food and forest products for all of these humans. Agriculture is particularly important. Agriculture already occupies one-third of the earth's surface, and could well determine whether forests can continue to occupy the one-third of the global land surface they have now.

The most critical decisions we must make for the quality of life in the 21st century—for our children and grandchildren—are on agriculture.

WE CANNOT CHOOSE BETWEEN PEOPLE AND WILDLIFE

Environmentalist have taken to implying that wildlife is so important that we can put wild creatures ahead of humans.

Regardless of how eco-activists feel, however, it is clear that we cannot let the people starve and still save the wildlife.

The Third World simply cannot hire enough game wardens to protect the wildlife if the people are really hungry. Ask the elephants and gorillas in Africa today, where tribes are dealing with lower death rates by extending low-yield organic farming into wildlife habitat.

The people will be fed. Unless they have already destroyed all of the wildlife habitat in their last desperate efforts to save their children before the famine carries them off.

That means higher food productivity is as vital to the wildlife as to the people.

The food challenge of the 21st century is to produce three times as much from our farming resources while reducing any negative impacts of farming on the environment.

GLOBAL FOOD SUCCESS PROSPECTS

All of the serious recent studies of world food production potential have reached the same conclusion: The world SHOULD be able to feed a human population much larger than the one we have, and even larger than the population that demographers expect when the new stability is reached in 2050 or 2075. (The overwhelming majority of the population growth will have occurred by 2040.)

That will not be easy or without cost.

But if we continue the current trends of progress in plant breeding, pest control, irrigation engineering, and improved farming systems, we should be able to provide caloric sufficiency for 9–12 billion people, and even have a margin to spare—without clearing more forest or plowing down more wildlife.

Third World countries have recently been raising their food production by 3.9 percent per year, more than double their population growth rate.

Per capita calories in the developing countries have risen 27 percent since 1962, and rose 6 percent in the 1980s.

Actual dietary gains have been even more important than the caloric figures suggest. Third World diets of the 1990s include far more cooking oil, meat, milk, eggs,

fruits and vegetables than earlier years. (As an example, China's annual fruit and vegetable consumption has risen 80 percent and 7 million tons in the past five years.)

The world also has the first results of biotechnology to draw on. Biotech rice plants that are resistant to rice tungro virus could save 7 million tons of rice production per year. Bovine somatatropin can raise dairy feed efficiency by 10 percent. Pork somatotropin will apparently let us produce hogs with one-third less fat, using 25 percent less feed grain.

Biotechnology (in the form of cloning and tissue culture) is also permitting us to increase the yields of tree crops in all parts of the world by four to six fold. While a Swedish natural forest is producing 3 cubic meters of pulpwood per hectare per year, and a Georgia yellow pine plantation is producing 15 cubic meters, a Brazilian plantation of cloned yellow pine is producing 50 cubic meters of pulpwood per hectare per year.

NO RECENT SLOWDOWN IN FARM PRODUCTIVITY

Contrary to some misleading reports, there has been no slow-down in Third World food production gains since 1984.

The doomsayers are using a slowdown in overall world cereal production to mislead the public.

The world cereal production statistics seriously understate the world's recent gains in food security:

—There has been only a slow increase in the grain production of the "rich" countries. The U.S. and the European Union have been trying to hold down their grain production because of surpluses. In addition, the former Soviet Union has disbanded its old command economy, and has not yet achieved any more effective economic organization. This has not meant hunger for the citizens of the former USSR, but rather a sharp shift from meat and milk to bread and potatoes.

—Cereal production in the developing countries 1984–1991 rose at 2.01 percent annually according to the FAO, compared with population growth of about 2.1 percent. However, this seriously understates the food gains, because (1) the developing countries have been shifting to higher-quality calories; and (2) Africa still eats mainly root crops, not cereals.

—Total food production in the developing countries rose 3.8 percent annually during the 1984–91 period, nearly double the LDC population growth rate of 2.1 percent.

A decade earlier (1975–81), developing countries' cereal production rose at 2.8 percent annually, but total food production rose only 2.86 percent. Population growth averaged about 2.3 percent.

Clearly, the poor countries' rate of gain in total food production per capita has been even higher in the past decade than the rapid gains in the 1970s.

Total food production in the 1975–81 period outstripped population growth by 24 percent. Total food production in the 1984–91 period outstripped population growth by 81 percent.

Some "crisis."

ECO-ACTIVISTS OPPOSE FOOD SECURITY NEEDS

Two major policy initiatives are critically needed if we are to meet the enormous challenge of tripling world food output while still preserving wildlife and the environment.

(1) We must make substantial further investments in high-yield farming technology, so that we can produce still more farm products from each acre we use for agriculture; and

(2) We must liberalize trade in farm products so we can use the best and safest acres to meet the challenge. (Asia will be eight or nine times as densely populated per acre of farmland as the Western Hemisphere.)

Unfortunately, the so-called "environmental movement" is working against both of these critically-needed policies—in the misguided "service" of the environment.

Too many environmental activists have taken their environmentalism to mean war against humanity and human progress. They want to "solve" the food problem only if it can be solved by suppressing human population growth and limiting human diets.

Unfortunately for so-called "environmental" policy priorities, population management cannot come strongly or swiftly enough to preclude the need for higher farm output.

Nor are the world's people becoming minimalist vegetarians. Just the opposite, in fact.

Too many of the environmental activists got started in the movement through a fear of man-made chemicals—particularly pesticides. They are unwilling to acknowledge either the safety of farm chemicals or their irreplaceable role in food production.

Organic farming, however, cannot save the world or its wildlife.

—Organic farming yields are one-half or less of the yields on the world's best mainstream farms. Accepting these low yields would mean plowing down millions of square miles of wildlife habitat for food production.

—Worse, the world probably has only about 20 percent of the organic nitrogen needed to support its current farm output, let alone the huge increase in production that will be needed by 2050.

—Organic farming cannot cost-effectively provide the year-round abundance and variety of fruits and vegetables needed to protect people from cancer and heart disease.

Now that the threat of nuclear war with the USSR has receded, organic farming represents the greatest single threat to humanity and the wildlife on this planet.

The environmental zealots' strategies are thus virtually certain to fail.

Population curves change very slowly. Poor people want large families; the kids are almost immediately useful in fields and handcrafts. Kids are the only social security in poor countries.

Population management begins to have an effect only after people become more affluent and better educated. Even then, birth rate reductions are driven more by economic growth than by government population policies, pills or posters (though these can help modestly).

Third World couples are not reading Worldwatch polemics on foregoing children. (They just have smaller families as they get richer.)

The best news on the population front, in fact, is that hundreds of millions of poor people are getting rich faster than any large group of people in the history of the planet.

They are getting affluent by ignoring the "politically correct" advice to socialize their economies, put "community" first, and suppress their urges to live better. They are doing it, instead, on a market-oriented capitalist model. They are getting rapidly into export-oriented manufacturing, to supply affluent markets opened to comparative advantage by the General Agreement on Tariffs and Trade (GATT).

The GATT is the major reason why China is today the world's hottest market for jetliners, and McDonalds has decided to enter the fast-food market in Hindu India. Trade is the key factor overcoming centuries of Spanish-style bureaucratic red tape in Latin America.

Because of freer trade, not condoms, the world has a fighting chance to restabilize its population at 9 billion people rather than 12 billion.

WE NEED AGRICULTURAL PRODUCTIVITY MORE THAN CONDOMS

By demanding population suppression instead of agricultural research and trade, people like Lester Brown and Paul Ehrlich are playing Russian roulette with the world's wildlife.

Far from being kind and gentle humanists, they represent a harsh elitism. They want a sparsely-populated world even if it takes the world's biggest famines and history's largest wildlife losses to get it.

There is nothing wrong with advancing population management. So long as we also fully fund international efforts to raise crop yields.

But the eco-activists are demanding population management instead of high-yield farming.

The U.S. Agency for International Development is cutting its agricultural research support, and shifting the funds toward population programs. It is doing so precisely at the recommendation of Lester Brown, the Worldwatch Institute, Zero Population Growth and most of the other environmental organizations.

And yet the jewel in the crown of international aid is the Green Revolution. It was brought about through the international agricultural research centers, organized under the Consultative Group on International Agricultural Research. These centers created the Green Revolution. Dr. Norman Borlaug credits them—and the worldwide network of preceding agricultural researchers—for his Nobel Prize wheat varieties.

The international centers are continuing the Green Revolution:

—They have produced high-yielding cassava for Africa, along with biological controls for the cassava mealybug and the green spider mite.

—They have produced hybrid sorghums which can radically increase African crop yields and tolerate more severe drought.
—They have produced bananas and plantains which resist the dreaded Black Sigatoka disease, which threatened to destroy one of the world's most important food crops.
—They have produced high-protein corn to relieve severe protein deficiencies in poor corn-eating countries.
—They have designed the miracle rice for the 21st century, which should increase rice production 50–75 percent by 2030 using less land for rice plantings.
—They have pioneered soil-saving farming systems for the Third World, including alley cropping and tied ridges.

These agricultural research centers have been funded since their inception by foreign aid. USAID itself has provided 25 percent of that support.

No foreign aid program has ever come close to matching the enormous success of the agricultural research program—and now we are gutting it.

We are gutting food production research as the world faces its biggest food challenge in history.

Why?

Why are the environmental organizations not demanding more high-yield agricultural research with all the fervor of an ACT-UP member demanding more AIDS research funding?

Why are the environmental organizations not cheering on the farmers who produce more food from fewer acres? After all, any acre that is farmed below its full productive potential threatens the plow-down of an acre or two acres of wildlife, somewhere else in the world.

Why are the environmental activists not picketing Capitol Hill demanding free trade in farm products so that much of Asia's food gap can be supplied from land already cleared and uncropped in the Western Hemisphere?

Instead, the eco-activists are demanding low-yield farming.

They are not only tolerating but encouraging the plow-down of the Indian barking deer and the chain-sawing of Indonesian tropical forests for soybean production?

They are insisting on farm trade barriers.

They are wrongheadedly but aggressively presenting organic farming as the global ideal.

The eco-activists are demanding that the food challenge not be solved by the only proven success strategy: Higher and higher crop yields on the best and safest farmland already cleared for food production.

If we had waited for population management to solve the food crisis of the 1960s and 1970s, we would have had billions of famine deaths—and we would have plowed down another 5–10 million square miles of wildlife habitat.

If we take the eco-activists' solution now, we will:

—*Depress world economic growth, and thus slow the recent rapid world progress toward population stability.* They would have us put all of our available capital into a needless "environmental" restructuring of the world economy. This would produce lots of jobs in the rich countries—but little productivity gain to improve living standards in the poor countries. Nor would it produce much in the way of environmental sustainability, any more than the asbestos removal or acid rain programs have produced meaningful gains to people or the environment. (Much of the Third World is likely to simply ignore the environmental "mandates;" China and India will burn more and more soft coal, and use refrigerants like Freon which they can afford and which have long service lives.)
—*Give up high-yield farming, especially its fertilizers and pesticides.* We would deliberately put our faith in an organic farming system which cannot feed today's population, let alone tomorrow's.
—*Put our foreign aid dollars into condom campaigns which will not do much to resolve the balance between food needs and farming resources.* We will do this instead of continuing the Green Revolution, which has been the greatest foreign aid success ever achieved for humanity and the environment.
—*Plow down 25–40 million square miles of wildlife habitat needlessly.* (If indeed, that much can take a plow.) Some of it, almost certainly in the rain forest, where research has now discovered ways to farm the rainforest land productively and sustainably.
—*Suffer enormously increased soil erosion.* The soil erosion increases will be primarily due to extending low-yield organic farming onto fragile and difficult soils. However, we would also be eliminating the newest and best farming systems ever developed to combat soil erosion. We would reject the soil-safe no-till and conservation-till systems because they depend on chemical herbicide rather than bare-earth farming to kill weeds.

—*Raise human cancer rates.* The FAO says 25 percent of the world's grain and oilseed crops are infested with toxins and mycotoxins which produce human health risks. America's are not, primarily because we protect the crops against the pests which damage the seeds and let in the toxins. Even more important, we need pesticides to provide the low-cost, abundant fruits and vegetables that cut cancer and heart disease deaths.

POLICY RECOMMENDATIONS FOR HAVING PEOPLE AND WILDLIFE

Let us thank the environmental movement for raising our consciousness on the environment. Let us thank them for rewriting the public policy priorities of the whole world.

But as history has shown, the revolutionaries who challenge the old order are not always able to organize the needed improvements. Fidel Castro could see the failures and inequities of the Batista regime—but could not organize an economy which would realize the hopes and aspirations of the Cuban people.

Lester Brown and the Worldwatch Institute are certainly trying to raise our consciousness about a world food problem.

Unfortunately, they misunderstand the nature of the problem.

Even worse, they are deliberately disregarding the proven success strategy for solving it.

To his credit, Lester Brown in 1974 recommended both population management and agricultural research. He even commended the work of the international agricultural research centers in his book "By Bread Alone."

Since his anointment by the environmental movement, however, he has loudly and consistently told us that agricultural research cannot do us any good.

—Brown has fraudulently claimed that the recent food production gains have come from "mining soil and groundwater" instead of from plant breeding and fertilizer.

—He has not only disregarded the enormous gains from plant breeding, but announced that agricultural technology "could not solve the world food problem since it had not bred a higher-yielding soybean." (Somehow, Brown knew that the soybean was almost the only crop which did not have a rapidly-rising global yield trend.)

—He has claimed the recent one-third reduction in U.S. soil erosion was produced by the 1990 farm bill instead of by herbicide-based farming systems.

—He has misrepresented world food production statistics in a vain attempt to cover up the most dramatic gains in world food security ever made, and obfuscated the contribution of agricultural research and farmer incentives in achieving those gains.

—He has claimed that the world would run out of fresh water for farming, when farming can readily triple the efficiency of its water use with relatively modest investments in sprinkler and tube irrigation systems, improved irrigation drainage and pricing water at its real cost.

GOING FORWARD FOR PEOPLE AND THE ENVIRONMENT

Let us go from this hearing with a new resolve to protect both the world's people and its wildlife, because we have no other real choice.

Let us go forward with a renewed pride in our research institutions and technologies and the knowledge they have produced which can resolve the resource conflicts by creating new resources.

Let us go forward with thanks to the activists who have stimulated environmental preservation.

Let us go forward using both population management and high-yield farming to the fullest reasonable extent—based on their true capacities to resolve food/population/wildlife/land use conflicts.

Realistically, that means a far higher priority on agricultural research and farm trade than current Federal policy and budget proposals have awarded.

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Dennis T. Avery directs the Center for Global Food Issues at the Hudson Institute. Avery grew up on a Michigan dairy farm and studied agricultural economics at Michigan State and Wisconsin. He has conducted policy analysis for the U.S. Department of Agriculture, the President's Advisory Commission on Food and Fiber, and the U.S. Commodity Futures Trading Commission. He served as the senior agricultural analyst in the U.S. Department of State from 1980–88. He is the author of *Food and Fiber for the Future* (1968), and *Global Food Progress* (1991). His forthcoming book is *Saving the Planet With Pesticides and Plastic: The Environmental Triumph of High Yield Farming.*

BIOGRAPHICAL SKETCH

DENNIS T. AVERY

Dennis Avery is an internationally known expert on the dynamic changes taking place in the world's ability to feed itself and still protect environmental resources. He is especially noted for his analyses of trends in food demand, agricultural productivity and global farm competition.

Avery is the principal author of Global Food Progress—a timely, readable overview of the world's farming resources, technologies and policies published by Hudson in 1991. His forthcoming book, Saving the Planet with Pesticides and Plastics, will claim environmental credit for high-yield farming, for the millions of square miles of wildlife habitat not plowed for food, the soil erosion not endured because we concentrated production on the safest acres, and the cancers not caused because we chemically suppressed the molds and toxins and offered ample supplies of low-cost chemically grown fruits and vegetables.

For nearly a decade, Avery was the senior agricultural analyst in the U.S. Department of State. He has also done policy analysis for the U.S. Department of Agriculture, and President Johnson's National Advisory Commission on Food and Fiber.

He has long been publicly optimistic about the world's ability to conquer hunger. His 1985 article in Science was titled: "The Global Bad News is Wrong." He has been quoted in such diverse publications as Time, The Washington Post, Earthwatch and Successful Farming.

Mr. Avery grew up on a Michigan dairy farm and studied agricultural economics at Michigan State and the University of Wisconsin. He now lives with his wife on a small farm in Virginia's Shenandoah Valley.

The Hudson Institute is a think-tank founded in 1961 by futurist Herman Kahn. Hudson tries to look as far into the future as is rational, emphasizing the potential of well-managed technology to resolve human and environmental problems.

CLOSING REMARKS OF SENATOR COCHRAN

Senator COCHRAN. Mr. Chairman, could I interject a "bravo"? I have to go to another meeting, but I want to thank you again for giving us the diversity that this hearing has provided. I congratulate you.

Mr. AVERY. Thank you, Senator.

Senator BUMPERS. Thank you very much, Senator Cochran, for being with us this afternoon.

Mr. Avery, you make me sorry I even called this hearing.

Mr. AVERY. That certainly was not my intent, Senator.

Senator BUMPERS. I think you and I agree on one thing; and that is that the problem, such as it is, has to be attacked in a two-pronged way.

Mr. AVERY. I would agree with that, sir.

Senator BUMPERS. I did not hear Mr. Brown say anything contrary to that. He may have said something in the past, but he assured Senator Cochran that he did, indeed, believe in aggressive research.

Mr. AVERY. I was pleased to hear it. That is the first time I have heard him say anything since 1974 that would endorse more funding for agricultural research. In the meantime, he has sold millions of books that did not do so.

Senator BUMPERS. I do not want to get into scientific or personal disputes between you and Mr. Brown. I am most anxious to hear from both of you. You, obviously, reach different conclusions on this.

Mr. AVERY. Well, it is true, Senator, Mr. Brown has been predicting these famines since the late 1960's. He has been publicly and radically wrong about the potential of agricultural research for 25 years; and I think it is time we recognize that he is not functioning as an analyst, but rather as an activist in favor of population management.

I do not have a problem with population management. I do have a problem with the misrepresentation of high-yield agriculture.

Senator BUMPERS. We have all agreed that the problem, while it is a problem for the future, it is not necessarily not a problem now. What I want to do—and one of the reasons or the purposes of this small hearing—is not to wind up like the guy on the tombstone that had engraved on there: "See? I told you I was sick."

I do not want us, 40, 50 years from now, to say, "See? I told you."

Mr. AVERY. I would certainly agree with Lester Brown that we face an enormous challenge.

Senator BUMPERS. Let me give you an illustration; not necessarily on behalf of Mr. Brown, but on behalf of my own State.

We have been doing, for the past 10 years, aquifer studies of the aquifers in the rice-producing area. And those aquifers are being rapidly depleted. You know that rice requires a lot of water.

What would you suggest to the people of Arkansas, the rice farmers down there, is going to happen in the future? We have roughly 1½ million acres of rice; the water is running low. And when the water is gone, they cannot turn to the Arkansas River, for example, because the sodium chloride content is too high, salt content too high.

What do you recommend to them? Just go on and deplete the aquifer?

Mr. AVERY. Well, Senator, I am at a bit of a disadvantage because I do not know the Arkansas water problems well enough. I did meet recently with your ricegrowers, the Riceland Cooperative board of directors. I do not know their problems well enough to know what answer I can give you on water conservation for rice in Arkansas.

In terms of world rice production, I can tell you that there are, according to the best agricultural research experts, one-half of a billion acres of inland wetlands in Western and Central Africa which could produce rice. I cannot guarantee to you that Arkansas will remain a rice-producing State.

But in terms of world production, if we can raise yields in the world by 50 to 75 percent in the next 30 years with plant genetics, and could—if we needed to—add another one-half of a billion acres of inland wetlands for wet rice production in Africa, that should go a considerable way toward mitigating the world's rice needs.

Senator BUMPERS. Mr. Avery, if this is not the kind of problem that Mr. Brown and I and others think it is, why are we losing tens of millions of acres of rain forest and other forests every year, to people who are desperately trying to get something to eat?

Mr. AVERY. Well, there are two problems, I think, Senator, in the rain forest, specifically.

The first problem is that we are doing a considerable amount of logging; and logging in itself is not necessarily bad, if it simply means the harvest of mature trees, and the forest is allowed to regrow.

It is almost certainly true that a considerable portion of the rain forest has been cleared by people who followed the loggers in, followed those logging roads, and began to try and subsist on slash-and-burn farming in the Amazon.

The real problem—and I focus particularly on Brazil, because the Amazon rain forest has been the focus of a very large portion of our concern—it has not been because Brazil has been short of food. It is because Brazil has been short of job opportunities outside the rain forest.

Most of the people who are poor in Brazil have, in spite of the lack of jobs, opted to live in a slum near one of the cities, with the sewage running down the center of the streets. A few of them have opted for a short, harsh, desperate existence as slash-and-burn farmers in the rain forest.

It will be up to the Brazilian Government to enlarge the opportunities for nonfarm jobs for their people. I think Argentina, Bolivia, Chile, and Peru are showing the way with better economic opportunities.

I think we can take some credit, through the GATT, for having allowed economic growth to spread more rapidly in the recent decades than it ever has in human history. I think Asia is a sterling example. The economic growth rates we are seeing there are a sterling example of generating nonfarm opportunities.

But again, to demonstrate the power, we do not need the Amazon for food production. We now have the research to use it that way. I hope we never will.

But Brazil's own plant breeders have bred acid-tolerant crop varieties—corn, soybeans, coffee, and forage crops—that can produce high-yielding crops on 200 million acres of unplanted arable land in Brazil; and apparently, on a billion acres of unplanted land in the whole Southern Hemisphere.

The acid savannas, which up until now have been tropic wasteland, are now available for productive cropping and ranching, if we should need them. And they do not carry a great deal of biological diversity.

I am saying that, if we really support agricultural research and technology in the decades ahead, we should not even need to produce on those acid savannas. We should not need any more cropland than we are using today.

And genetics are the big key to it, followed by irrigation, fertilizer, and pest control.

Senator BUMPERS. Mr. Avery, I do not quite know how to say this, but it seems to me that in a sense—let us just take Brazil, for example—you are saying that, if those people would just do this, this, and this, they would not have a problem.

And, while I understand what you are saying, they have some very unique problems there. They have found, for example, that an awful lot of the land that they tried to convert to soybeans simply

would not grow soybeans. As a matter of fact, they found it would not grow much of anything, except what it was growing: Either trees or grass.

No. 2, you say, "If they would find jobs for their people." My God, what a big "if"! That is like saying, "Why do we allow 25 percent of the children in this country to live below the poverty line? Why do we not give them something? Why do we not give their parents jobs? We would not have this problem."

And when you consider the fact that Brazil's population has tripled, has tripled, since the end of World War II, you know, I just do not see any way on Earth—given the geography, the texture of their land, the rain forest, everything else——

People were given 2 hectares of land in Brazil, to go to the rain forest. They gave people in the barrios a couple of hectares of land, and they all went out to the Amazonian rain forest and whacked away, and cleared 2 hectares, roughly 5 acres; and when they got it cleared, they realized they had not accomplished anything—because it would not grow anything. They had made a little crop the first year, and that was the end of it.

Many of them got diseases; most of them were hungrier than they were in the barrios. And they have gone back to Rio and Sao Paolo, just as hungry as they were when they left.

Mr. AVERY. Senator, we have discovered that one crop of kudzu does as much for soil fertility as 14 years of bush fallow. This opens the way—and it terrifies me—this opens the way to farm successfully the rain forest, as we have not been able to do in the past.

I do not want to farm the rain forest. I do not even want us to have to farm those tropical wastelands, the acid savannas.

The alternative, along with whatever we are able to achieve with population management—but we are not going to get through population management a stabilization in the world population anything short of 9 or 10 billion people. There simply is not, it does not work that fast; and it does not work with people in the poorest stages of economic development. In order to use population management techniques, people have to want fewer children.

I was in Egypt in 1981. They had just done a survey of women in the Upper Nile, asking them how many children they wanted. Their answer was 16.

And this should not surprise us because, in a poor country, children are one of the few assets that poor families can have. They are almost immediately useful in the fields, in the handicrafts.

In a rich country, children are an expensive luxury; and I have just put my third son through college. And it should not surprise us a bit that the World Bank rankings of countries by per capita income are almost exactly the reverse of the ranking of countries by birth rate.

The Third World has already come 60 percent of the way to a 1-to-1 ratio between births and deaths, and they have done it, basically, in one generation; and I think they should be applauded for it. But I think we need to recognize that affluence is the biggest spur to population stability.

Senator BUMPERS. I see it in slightly different terms. When I see countries like China—I was in China about 12 years ago, no, 15

years ago—they have increased their population by roughly 200 million since I was there, 150 million, maybe.

And you think about countries like Brazil. There is not a thing in God's world you can do today for Somalia, Sudan, all of those countries in Africa. Nothing. You can put all the agricultural research you want to on the table. They do not have the rainfall, they do not have the arable land.

There are 5.2 billion people on Earth today, and probably somewhere between 1.5 and 2 billion of them go to bed hungry every night.

Maybe it is just a distribution problem.

Mr. AVERY. Senator, to some degree it is a distribution of resources problem; and that is why I highlighted the population density that we will have in Asia in the 21st century, and the importance of using the good safe cropland that is already cleared in the Western Hemisphere—some of it in Arkansas—to help meet that food gap.

But we really have—other than a few countries, a few regions in fact, like the Sahel, possibly parts of Somalia, the highlands of Nepal—not the lowlands, but the highlands—there are very few places in this world that we do not, that I do not foresee providing adequate base calories for their own populations, expanded as we expect them to be, through higher yielding agriculture; if we pursue it.

My only real fear is that we will turn our backs; that the chemophobia that runs rampant in this country will cause us to turn our backs on the proven, successful approach for fighting famine and preserving environmental resources on this planet. And that proven success approach—we all recognize we are going to get zero population growth, but we are not going to get it soon enough to preclude the need for more, and important, agricultural productivity gains.

Senator BUMPERS. Mr. Avery, let me just conclude with this thought; and if you want to comment on it, be my guest: The world's population at this very moment is 150 percent more than it was when I was in the first grade; because I can remember my first-grade teacher telling me the population was 2 billion people. I did not know what a billion was; but I remember that.

So now we have 150 percent population in less than my full lifetime, increase. And that population, not just in this country but especially in the Third World where the population growth rate is much greater and where the resources are much less, and their agricultural know-how is much less, when you consider the tremendous pressures that the world's population growth puts on our environment, it is my firm opinion that the environment cannot forever sustain.

As a matter of fact, it is being degraded at a very rapid rate, because of the population of the Earth; and people scavenging for food, destroying precious resources irreversibly; and you know, I think that as I say, you and I agree basically that it takes a two-pronged attack.

But I just have a feeling that somehow or other, I get the impression from you that if we just turn the private sector loose with enough money to do all the research that needs to be done, the rest

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of it would become a nonproblem. The population growth rate would become a nonproblem.

And as I say you mentioned correctly that we have made virtually no increases in soybean production. And we have hybridized corn—maybe we have not gone as far as we can go—you know, corn production, if my father knew that farmers in the Midwest made 200 bushels of corn to the acre, he would not believe it.

There has to be a limit to all things. You simply cannot continue with some of the rapid and dramatic growths in food production that we have had in the past. And as I just told you a moment ago, the classic case in point is for Arkansas rice farmers.

So as I say, I do not know when we are going to get serious about it. And you know, this is just sort of an exercise in futility because, as I say, nobody really much cares about it now. A few people like you and Lester Brown study it and think about it. But not very much—I do not want to hurt your feelings—not very many people pay any attention to what you are saying.

Mr. AVERY. Senator, I do not deny that it would make all of us much more comfortable if the people of the Third World would stop having children tomorrow; that we could stabilize population the day after tomorrow, and breathe a great sigh of relief.

Those are not decisions made in the United States. Those are not decisions even made by the governments of the countries where the population growth is largely occurring. Those are decisions made by billions of people who have to be reached individually; and they are not yet reading the publications of the Worldwatch Institute.

If we want to preserve the environmental resources of this planet, the major thing—again, I subtract nothing from population management; we certainly should pursue population management strategies—but the one major, proven, rapidly working policy that we can follow is to support agricultural research and technology.

And, on your specific point of soybeans, I will alert you to the fact that last year in Saudi Arabia, they grew 1,000 hectares of a new crop called salacornia biglioveae. It is a ubiquitous saltwater weed around the world. If you plant it in fields, and chop it green, it is a high-protein cattle feed like alfalfa. If you allow it to mature, it is an oilseed with a yield and a protein meal proportion very similar to the soybean.

The tricky thing is, you grow it on the desert and you irrigate it with seawater; and suddenly any coastal desert in the world, where you can pump the seawater ashore and have it run back into the ocean instead of contaminating an aquifer, is saltwater soybean land.

Senator, we have resources we do not even know about. And to throw up our hands, to turn our backs on agricultural research, to say that we cannot do it, would be the greatest mistake we could make for the fate of our grandchildren.

Senator BUMPERS. I agree with part of that.

Mr. AVERY. Thank you, sir.

Senator BUMPERS. Thank you, Mr. Avery.

DEPARTMENT OF AGRICULTURE

AGRICULTURAL RESEARCH SERVICE

STATEMENT OF DR. EDWARD KNIPLING, DEPUTY ADMINISTRATOR, NATIONAL PROGRAM STAFF

ECONOMIC RESEARCH SERVICE

STATEMENT OF DR. ROBERT ROBINSON, DIRECTOR, AGRICULTURAL TRADE ANALYSIS DIVISION

INTRODUCTION OF WITNESSES

Senator BUMPERS. Our next two witnesses may both come forward at the same time.

Edward Knipling, Deputy Administrator, National Program Staff, ARS. Dr. Knipling has been with the USDA's Agricultural Research Service since 1968.

Mr. Robert Robinson, Director, Agricultural Trade Analysis Division, Economic Research Service. Dr. Robinson was an associate administrator of the Economic Research Service; is the leader of the U.S. delegation to the OECD Committee for Agriculture; and is Executive Director of ERS' Eastern and Central Europe Technical Assistance Program.

Gentlemen, thank you very much for coming this afternoon. Mr. Knipling, you are first on the list, so please proceed.

STATEMENT OF DR. EDWARD KNIPLING

Dr. KNIPLING. Thank you, Mr. Chairman. First, I appreciate the opportunity of participating in this discussion this afternoon on the adequacy of the world's food supply.

This issue is certainly of fundamental concern to the Department, in that our research mission is to provide the knowledge and technologies required to ensure, perpetually, an adequate supply of high-quality food and fiber for the American people and for export. This has been true in the past, and will certainly be true in the future.

In the 1994 State of the World Report, the authors argued that humankind finds itself at a crucial point in history, where the demands on natural resources exceed the sustainable supply. They draw attention to an ever-increasing world population, and the diminishing resource base for expansion of food production.

Now, these future projections of population growth and food production at first glance appear to be sobering. We acknowledge that the rate of increase in unit yields of some crops has slowed in recent years, and that the opportunities for expanding the land area used for food production are declining.

NEW TECHNOLOGY

However, on further analysis, these trends can be considered to be encouraging as well. We note that the rate of global population increase is slowing. We are also encouraged by the reminder that the development and adoption of research-based new technology has succeeded in the past in creating tremendous increases in agricultural productivity worldwide.

We firmly continue to believe that additional new developments in technology hold promise for increasing the efficiency of production on the existing land base and other future gains. At the same time, we do recognize that increased agricultural production at the expense of the environment, and in a manner that is not sustainable over time, is unacceptable.

Finding a balance between protecting resources and increasing production is a difficult challenge, but mandatory for the long-term survival of humankind.

Thus, we not only need to adapt existing technology and develop new technology that leads to increased production, but we must assure that production can be sustained without loss of natural resources or unacceptable modification of the environment.

We concur with the State of the World Report that the development and implementation of environmentally sound and sustainable methods of increasing food production is an urgent need. As has been pointed out here before this afternoon, now is the time to make the necessary investments in research and technology development, to achieve this goal.

The scientific discoveries and technologies that are emerging from the research pipeline have their origins with research that was initiated 10, 20, or 30 years ago; and the new generations of technologies that will be needed two or three decades from now must have a jump-start today. Already, USDA directs its research and development programs toward these goals.

Traditional examples that are still very important are: research on the biocontrol of weeds; plant and animal breeding for disease resistance and improved performance; tillage studies to increase soil organic matter, enhance water utilization, and reduce erosion.

Equally important are applications of the new tools of biotechnology and advanced information systems to technical agricultural problems. In contrast to the statement by Mr. Brown earlier, these are two broad areas that I do think represent the great potential for the future.

Examples are plant and animal genome mapping; genetic engineering for improved food quality and production; sensor-based prescription farming; computer models to aid farmer decisions for agricultural production and natural resources protection.

The agricultural research community, both public and private, is investing heavily in these areas now; and we are very confident and excited that such programs will allow us to meet the food production and sustainable agricultural challenges facing the world.

GERMPLASM REPOSITORIES

An essential public resource that undergirds all agricultural science and technology improvements are germplasm repositories.

The United States is a world leader in preserving and maintaining genetic diversity in the form of a network of seed banks and other life-form collections.

Increased public attention, worldwide, must be given to the protection of these natural resources, and to systems and policies for enhancing international accessibility to them, in order to sustain future technological improvements needed in food production.

World food security is, literally, dependent upon protection of the world's existing genetic resource base.

In conclusion, I believe that the Worldwatch Institute has, in fact, highlighted matters of concern. However, the research conducted by USDA and our university and industry partners has made great strides in the last 50 years in providing technology to the producers of this country and the world.

We are confident that this progress will continue, and that future world food needs will be met and can be met.

Support for future research and education programs will, of necessity, need to explicitly emphasize natural resource conservation, while developing the technology necessary to enhance agricultural production.

PREPARED STATEMENT

Senator BUMPERS. Thank you, Dr. Knipling, for your testimony. We have your complete statement and it will be made part of the record.

[The statement follows:]

STATEMENT OF DR. EDWARD B. KNIPLING

Mr. Chairman, I appreciate the opportunity to participate in this discussion regarding the long-term adequacy of the world's food supply. This issue is of fundamental concern to the Department of Agriculture in that our research mission is to provide the knowledge and technology required to ensure, perpetually, an adequate supply of high-quality food and fiber for the American people and for export. This has been true in the past and will continue to be true in the future.

In the 1994 State of the World report, the authors argue that humankind finds itself at a crucial point in history, where the demands on natural resources exceed the sustainable supply. They draw attention to an ever increasing world population and a diminishing resource base for expansion of food production.

The report covers a number of topics, some of which are outside the purview of the Department of Agriculture. However, we would like to address some of the main issues that do concern us, particularly the manner in which technology has altered and will continue to alter the relationship between population growth, food production, and natural resource use.

The future projections of population growth and food production at first glance appear to be sobering. We do acknowledge that the rate of increase in unit yields of some crops has slowed in recent years and that the opportunities for expanding the land area used for food production are declining. However, on further analysis these trends can be considered to be encouraging. We note that the rate of global population increase is slowing. We are also encouraged by the reminder that the development and adoption of research-based new technology has succeeded in the past in creating tremendous increases in agricultural productivity worldwide. We believe that additional new developments in technology hold promise for increasing the efficiency of production on the existing land base and other future gains.

At the same time, we must recognize that increased agricultural production at the expense of the environment and in a manner that is not sustainable over time is unacceptable. Finding a balance between protecting resources and increasing production is a difficult challenge, but mandatory for the long-term survival of humankind.

Thus, we not only need to adapt existing technology and develop new technology that leads to increased production, but we must assure that such production can be

sustained without loss of natural resources or unacceptable modification of the environment.

We concur with the State of the World report that the development and implementation of environmentally sound and sustainable methods of increasing food production is an urgent need. Now is the time to make the necessary investments in research and technology development to achieve this goal. Science discoveries and technologies emerging from the research pipeline today had their origins from research initiated ten, twenty, and thirty years ago. The new generation of technologies needed two or three decades from now must have a jump start today.

Already USDA directs its research and development program towards these goals. Traditional examples that are still very important are research on biocontrol of weeds and insects; plant and animal breeding for disease resistance and improved performance; and tillage studies to increase soil organic matter, enhance water utilization, and reduce erosion.

Equally important are applications of the new tools of biotechnology and advanced information systems to technical agriculture problems. Examples are plant and animal genome mapping, genetic engineering for improved food quality and production, sensor-based prescription farming, and computer models to aid farmer management decisions for farm production and natural resources protection. The agricultural research community is investing in these areas and we are confident and excited that such programs will allow us to meet the food production and sustainable agriculture challenges facing the world.

The Department currently is putting increased emphasis on ecosystem management. Rather than considering one component at a time, planning and assistance are attempted in a holistic fashion where the total resource base, including people, is taken explicitly into account. Also in research, we are giving attention to total farming systems in which the various interactions among components are recognized and economic well being is achieved in harmony with resource conservation.

An essential public resource that undergirds all agricultural science and technology improvement programs are germplasm repositories. The U.S. is a world leader in preserving and maintaining genetic diversity in the form of a network of seed banks and other life form collections. Increased public attention worldwide must be given to the protection of these natural resources and to systems and policies for enhancing international accessibility to them in order to sustain future technological improvements needed in food production. World food security is literally dependent upon protection of the world's existing genetic resource base.

Beyond USDA programs we are encouraged that in recent years the U.S. Agency for International Development has stressed sustainable agriculture and sound soil management in its Collaborative Research Support Program. Similarly, the World Bank has recently concluded that short-term economic return is not the most appropriate criterion for its program of developmental assistance and now considers environmental values and sustainability as it develops its portfolio.

In conclusion, we believe that Worldwatch has highlighted matters of concern. The research conducted by USDA and our university and industry partners has made great strides in the last 50 years in providing technology to the producers of this country and the world. We've brought agriculture from the horse and plow to today's level of technology. We are confident that this progress will continue and that future world food needs can be met. Support for future research and education programs will, of necessity, need to explicitly emphasis natural resource conservation while developing the technology necessary to enhance agricultural production.

Mr. Chairman, this concludes my prepared statement. I will be pleased to respond to questions and participate in the discussions.

Biographical Sketch

DR. EDWARD B. KNIPLING

Dr. Knipling was born in Texas in 1939, but grew up primarily in the Washington, D.C. area. He earned his BS in 1961 in forestry from Virginia Polytechnic Institute in Blacksburg, Virginia. He received his M.A. in 1963 and Ph.D. in 1966 in plant physiology from Duke University.

Dr. Knipling served in the U.S. Army 1966–68, conducting research on remote sensing of environment. He began his career with the USDA, Agricultural Research Service (ARS) in 1968 as a research plant physiologist in Gainesville, Florida. He has also served as Area Director for ARS in Stoneville, Mississippi (1975–78) and in Fresno, California (1978–82), and Associate Deputy Administrator, National Program Staff, Beltsville, Maryland (1982–88). Dr. Knipling served as Director of the Beltsville Agricultural Research Center, Beltsville, Maryland (1988–89), and cur-

rently serves as Deputy Administrator of the National Program Staff, Beltsville, Maryland.

STATEMENT OF DR. ROBERT ROBINSON

Senator BUMPERS. Dr. Robinson.

Dr. ROBINSON. Thank you, Mr. Chairman. I appreciate the opportunity to be here today, to discuss the world's food situation.

The Worldwatch Institute recently issued a report which Mr. Brown summarized, and Mr. Avery critiqued. But in our view, it had three major components of concern.

One was the concern about population growth, which has been articulated well by yourself and others here today; the second is the food production potential of the planet, declining due to degradation of the basic resources needed for food production; and third, an assumption—or a proposition—that we are near or possibly exceeding the upper limits of a sustainable food production on the Earth.

Our view is different.

While many of these concerns are very real, as has been discussed, we must remember that with the technology in use only 50 years ago, in your childhood and mine, we could not feed the world as we have it today.

ADEQUACY OF PRODUCTION CAPACITY

Based on our assessment of the global resource base, technological changes and productivity growth, consumption and population growth, we believe the world's food production capacity will be adequate to feed a growing population in the 21st century.

Realizing, of course, as was pointed out a moment ago, that population, growth in the population rate is a very important variable in that equation, U.N. data suggests to us now that the population growth rate has decreased from 2 to 2.5 percent in the sixties, to 1.7 percent in the eighties; projected to be 1.4 percent soon after the turn of the century, to 1 percent by 2025, and leveling off at about a zero growth rate by the middle of the next century.

Senator BUMPERS. Who makes that projection?

Dr. ROBINSON. That is a U.N. projection, a United Nations projection.

We recognize that agricultural resources are under pressure, as you point out, particularly in some parts of the world. Some countries, developed countries particularly, have food surpluses; and other countries are facing food shortages.

Large food problems are generally localized in specific areas of the world. Problems do exist. A few countries seem to be in a perpetual food shortage situation. In some countries, significant pressures are being exerted on the natural resource base, to increase production. In other countries, such as the developed world, intensive production has led to environmental degradation.

ERS ANALYSIS OF FOOD SUPPLY

However, our analysis simply does not support the kind of imbalance that has been projected in Worldwatch Institute's report. Let me describe, if I may, some of our conclusions.

World food production, over the past four decades, has more than doubled; and the annual production growth has exceeded the rate of population growth by one-half of a percentage point per annum. Much of that growth stems from technical change, research, innovation, development, and adoption of productive, production-enhancing technologies.

An assessment of yield data from most countries around the world indicates that yield growth is not slowing down. Although the rate of growth, as pointed out in the table in my written remarks, is not stable from year to year, it does remain positive.

It is in the last 2 or 3 years that world population growth exceeded the growth in food production. Our assessment of the decline in global per capita food production over the last few years leads us to conclude differently from Worldwatch Institute.

Our conclusion is that a short-term, and reversible, set of policy decisions—and not a permanent loss in global production capacity—is the underlying causal factor.

The world has not reached, nor is it near, the upper limits of production capacity.

Fertilizer use, one of the variables used, has in fact declined somewhat in the last several years. But, if one looks at the stimulus for production use, that is, price incentives in the developed countries, and if one segregates fertilizer use into developed and developing countries, we find that developed country fertilizer use has declined as acreage is withdrawn from production. Developing country fertilizer use continues to increase.

POLICIES OF DEVELOPED COUNTRIES

Most of the decline in food production growth in the past 3 years took place in North America, Western Europe, and the former Soviet Union. Both North America and Western Europe were concerned with excess production capacity.

Farm programs in this country, along with the Conservation Reserve Program, have withdrawn in 1992–93, approximately 46 million acres of land from production. That is about one-sixth of the historical U.S. crop acreage that is not in production.

In Western Europe, primarily the European Union, they have been struggling with a structural surplus in their agricultural sector for some time, which created the need to subsidize exports and to hold large quantities of stocks: Subsidies on exports is one of the big issues that the United States has been dealing with, in fact, in GATT negotiations.

As part of an effort, a recent effort to control its surplus production capacity, the European Union as well has introduced policies to remove agricultural land from production. Currently, approximately 4.3 million hectares, or about 11 million acres, are removed from production.

A significant increase in world prices would bring this land back into production. Which leads me to yet another point. If one looks at the price of food over time, there has been a decline in the price of food. The market itself would indicate that, on a global level, there is no problem with food availability. The problem is distribution, and the income to buy food.

FORMER SOVIET UNION

Third, the fall in the former Soviet Union grain production has also been mentioned, but is considered to be a short to intermediate term phenomenon.

Analyses by our Economic Research Service indicates that, as the former Soviet Union moves toward a market economy and begins to adjust to the tremendous reform that is under way, they should become once again efficient producers; and, in fact, potentially exporters of grain.

Now, while the trend in food output has increased more than population growth since the 1950's, let me hasten to add that the opposite is true of some regions such as sub-Saharan Africa, and South Asia.

FOOD SITUATION IN DEVELOPING COUNTRIES

The Economic Research Service makes an annual assessment of the food situation in 60 developing countries. Our assessment indicates that more than one-half of the 60 are food-deficit, and would require approximately 14 million tons of food aid in 1993 and 1994, to maintain a per capita grain consumption at the average of the last 5 years.

I think it instructive to think of those 14 million tons of required food aid as having two components. One is a short-term, emergency food needs component which can be identified with short-term weather movements, with civil strife, and with other related short-term phenomena.

Another is a longer term structural food needs component. Well over three-fourths of the calculated food aid needs in any year are structural in nature. These chronic food shortages develop when a country's capacity to produce simply cannot keep pace with its population growth.

In sub-Saharan Africa, crop production per acre has increased by only about 15 percent in the past 20 years, less than 1 percent per year. In many countries of sub-Saharan Africa per capita food production levels are below the levels of 1970.

Income problems, even in the face of huge decline in food prices, do not permit these countries to import. As a result, food aid has been a means of providing food.

However, if one does look at the statistics that are produced by FAO, one finds that if we take 2,000 calories as a base, that in about 1960, 74 percent of the world had diets less than 2,000 calories. In 1990, it was less than 6 percent. So, that is really a major move forward in terms of redistribution of available food.

Policy decisions in North America and Europe are actions that could be changed from a policy point of view, and weather-related events, such as production shortfalls in sub-Saharan Africa, will always be with us. However, factors such as this, as you point out, remind us of the thin margin between plenty and scarcity, an imbalance of too much and too little.

FOOD PRODUCTION IN THE FUTURE

I have enumerated in my paper several long-term food availability issues, but those have been discussed in some detail here this

afternoon. So, perhaps what I would do is to move from those and talk in summary about how the future looks from our point of view.

It is true that the supply of land and water for agricultural production is limited and that the resource base in many cases is being taxed and degraded by improper use. However, there already exist technologies which, if adopted more broadly, could increase the efficiency of water use and could increase the efficiency of land use.

With appropriate technology and practices, much of the land currently being lost through erosion and salinization could be reversed or preserved. An additional issue is that some marginal lands could, in fact, be brought back into production in an environmentally sound way.

While land and water degradation pose serious problems, as mentioned by my colleague, Dr. Knipling, it does not appear to be a cause for concern about the ability to provide an adequate food supply over the next two or three decades. Corrective action, as you point out, is necessary, however, if many of the developing countries are to achieve sustainable agricultural production.

Another positive factor, and not discussed very much here except by Senator Cochran with respect to food production, relates to the issue of farming the oceans and the related issue of aquaculture production. Farming the oceans is not unlike wild range or open range farming of cattle. It is not the most efficient use of that resource in many cases.

Aquaculture production, as has been pointed out, is one activity which is more—if you will liken it to beef production or pork production or poultry production—of a confinement operation of the species. Aquaculture, for example, already accounts for approximately 25 percent of worldwide shrimp and salmon production and consumption. As harvesting limits are reached or are placed on more species, aquaculture perhaps holds the technological potential to fill the gap.

Technology breakthroughs are always difficult to predict. However, there is a significant stock of technology which has not yet been adopted especially in low income, developing countries. Growth, as pointed out by Dr. Knipling, is coming from genetic improvements in seed varieties and other technological improvements, not simply from increased use of fertilizer or other chemical inputs.

There is no indication that this trend in technological change and improved productivity is diminishing over time, particularly at a time when biotechnological innovations such as genetic engineering appear to offer great potential for increasing agricultural productivity.

However, two serious problems must be dealt with as these areas of science produce technology, if it is to have a positive impact on world food supply. One of those problems, which is already being confronted, is that the possible negative effects of these technologies on the world's environment must be considered and eliminated, and the safety of food for human consumption must be resolved.

The other, is whether the new technology in fact can be adopted in those areas of the world where food production pressures are

greatest, and help alleviate the food shortages where they currently exist.

Almost as difficult to predict as technological breakthroughs are the major policy breakthroughs. Nevertheless, I believe there is significant evidence that a major shift in the global policy environment is before us.

Countries have for years pursued policies which in fact were protectionist in nature. They distorted signals to producers. Producers in some countries produced too little because the price signals were too low artificially. Producers in other countries produced too much because the price signals were too high artificially.

By eliminating these through agreements such as we have just had in the General Agreement on Tariffs and Trade in the Uruguay round and in NAFTA and in other such relationships, many of those barriers and distortions are beginning to be eliminated.

Additionally, many countries are beginning to pursue, as was Mexico, unilateral restructuring or a reform process of their agricultural sectors. Such reforms once again offer the potential for producers to produce relative to market signals and, perhaps, the productivity gap between the developed and developing countries could begin to narrow.

Mr. Chairman, on balance it appears to us that in the next two to three decades the longer term phenomena that are causing concern do not pose an insurmountable obstacle to the world's food system.

In this timeframe, food crises will likely continue to be localized as a consequence of policy induced inflexibilities in the global food system and due to a lack of effective demand, as I mentioned a moment ago, rather than a failure of supply based on production potential.

In the longer term, there are threats to the productive capacity of the world. You yourself have enumerated those. However, there is little doubt at least in my mind that there are means by which such dangers can be avoided, and there is time to implement these actions on both sides of that equation, both in production and in population.

It is critical to the well-being of future generations that the countries of the world move expeditiously to take necessary actions to ensure the continued ability to provide adequate food supplies at a reasonable cost for our respective populations.

Mr. Chairman, that completes my testimony on world food production, and I will be glad to respond to your questions.

PREPARED STATEMENT

Senator BUMPERS. Thank you, Dr. Robinson, for your testimony. We have your complete statement and it will be made part of the record.

[The statement follows:]

STATEMENT OF B.H. ROBINSON

Thank you Mr. Chairman, I appreciate the opportunity to be here today to discuss the world food situation. The Worldwatch Institute recently issued a report which took a view of the world food situation that can best be summarized by two propositions: (1) The food production potential of the earth is declining due to degradation of basic resources needed for food production (land, water, and air) and (2) We are

currently near, and possibly exceeding, the upper limits of sustainable food production of the earth.

Our view is different. Based on our assessment of the global resource base, technological changes and productivity growth, consumption, and population growth, we believe the world's food production capacity will be adequate to feed a growing population as we enter the 21st century. We recognize that agricultural resources are under pressure, particularly in some parts of the world. Some countries, developed countries particularly, have food surpluses, and other countries are facing food shortages. There are concerns about food availability and real concerns about a pending food crisis where world population and food needs outstrip production capacity. Our data and analysis as well as the analysis of other research organizations do not support the notion of a pending food crisis except in certain localized situations. Problems do exist. A few countries seem to be in a perpetual food shortage situation. In some countries, significant pressures are being exerted on the natural resource base to increase production. In other countries, intensive production has led to environmental degradation. Other countries have population growth rates in excess of both short and long-run food production growth rates. Still other problems exist related to food distribution and short-run production shortfalls. However, our analysis does not support a long-term crisis or gross imbalance between overall food production and food needs. Let me describe some of our conclusions about the world's food supply.

GLOBAL FOOD PRODUCTION AND THE NATURE OF THE FOOD CRISIS

World food production over the past four decades has more than doubled and the annual production growth rate has exceeded the rate of population growth by about one-half of a percentage point. In other words, global per capita production has increased on average nearly 0.5 percent per year. Much of that growth stems from technical change—research, innovation, development and adoption of productivity enhancing technologies. An assessment of yield data from most countries around the world indicates that yield growth is not slowing down.

Although the rate of growth is not stable from year to year, the rate of yield growth remains positive.

GRAIN YIELD GROWTH RATES

[Percent per year]

Commodity	1951–60	1960–70	1970–80	1980–90
Wheat	1.84	3.06	1.99	2.89
Rice	1.27	2.4	1.63	2.34
Maize	2.74	2.48	2.84	1.01

Source: *The World Food Outlook*, World Bank, 1993.

It is only in the last two or three years that world population growth has exceeded the growth in food production. Our assessment of the decline in global per capita food production over the last few years leads us to conclude that short-term, and reversible, policy decisions, and not a permanent loss in global productivity capacity is the underlying, causal factor. The world has not reached nor is it near, the upper limits of its food production capacity. In short, we are not on the brink of a global food crisis.

Most of the decline in food production growth in the last three years took place in North America, Western Europe, and the former Soviet Union (FSU). On closer examination, it appears, the decline in the North America and Western Europe can be attributed to current policies designed to remove resources from production in order to control excess production. For example, the United States had about 16 million acres of land held out of production by annual government commodity programs in 1992/93 and another 36.4 million acres in the Conservation Reserve Program. Thus, about one-sixth of the historical U.S. crop acreage was not in production.

The European Union (EU) has also been struggling with a structural surplus in its agricultural sector, requiring the subsidized export or stockholding of large quantities of grains, beef, and dairy products. Currently, EU grain stocks stand at just below 22 million tons, despite continued efforts to control production. Our analysis indicates that the EU is likely to remain in structural surplus for grains despite recent reform of the Common Agricultural Policy (CAP). As part of its effort to control surplus production, the EU has introduced policy measures that remove agricultural land from production. Currently, approximately 4.3 million hectares (10.6 million

acres) of land are entered in the annual set-aside program introduced as part of CAP reform. In addition, other land remains in a 5-year set-aside program introduced in 1988. The EU Commission can reduce the set-aside rate it requires (currently 15 percent) in any year. A significant increase in world prices would likely bring this land back into production.

The fall in FSU grain production may also be a short-to-intermediate phenomenon. Analysis by our Economic Research Service (ERS) indicates that as the FSU moves toward a market economy, it should become a more efficient producer which could lead to higher production levels, especially in grains.

Now, while the trend is that world food output has increased more than population growth since the 1950's, the opposite is true in some regions such as Sub-Saharan Africa and South Asia. ERS makes an annual assessment of the food situation in 60 developing countries. Our assessment indicates that more than half of the sixty countries are in a food deficit and would require 14 million tons of food aid in 1993/94 to maintain per capita grain consumption at the average of the last 5 years.

It is instructive to think of the 14 million tons of required food aid as having two components—a short-term emergency food needs component, and a longer-term structural food needs component. Much of the year-to-year change in the food aid needs assessment is a short-term, weather- or civil strife-related phenomena. For example, this year Sub-Saharan Africa's needs remain high but are below last year's needs because of a production recovery. The largest change in food aid needs is in Southern Africa, where the grain harvest in 1993 was more than double the drought-devastated harvest of a year earlier. In addition, the renewal of the civil war in Angola has disrupted food production and distribution in that country.

Well over three-fourths of the calculated food aid needs in any year are structural in nature. These chronic food shortages develop when a country's capacity to produce or to commercially import food is unable to meet population growth on a regular basis. Agricultural productivity has increased at an annual rate of over 2 percent in the developed countries over the past 20 years. In Sub-Saharan Africa, crop production per acre has increased by only 15 percent over the same period—well less than 1 percent per year. In many countries of Sub-Saharan Africa, per capita food production levels are below levels of the 1970's. The productivity gap between the developed and the developing countries, particularly the poorest developing countries, appears to be widening. Only those countries facing severe resource and productivity constraints, and lacking income for commercial food imports (mostly in Sub-Saharan Africa and South Asia) can be said to be in a state of food crisis.

Policy decisions in North America and Europe, and weather-related production shortfalls in Sub-Saharan Africa are short-term. Policy actions can be changed and weather-related events will always be with us. However, factors such as these are persistent reminders of the thin margin between plenty and scarcity, an imbalance of too much and too little.

PRESSURES ON LONG-TERM FOOD AVAILABILITIES

Before I delve into our view of the future for global food production, let me turn to a review of the factors that give some observers cause for concern about the longer-term global food situation—population and income growth, resource and productivity, and food policies. All three factors are important in considering the long-run balance between food availabilities and food needs.

Population and Income Growth.—A major factor in assessing the long-term adequacy of food supplies is growth in aggregate demand—population and income growth. Sufficient income growth could provide a mechanism (trade) for countries to satisfy the growing food needs of their population. The expected growth in incomes and the concurrent expansion in food demand, overall, could add pressure on food supplies and extend food availability concerns in the poor, chronically food deficit countries. The world population growth rate is expected to decline, from 1.8 percent per year during 1980–90 to 1.4 percent per year by 2010. But, even with the population growth rate declining, the world will add over 90 million people per year, with virtually all of the increase in the developing countries. If world population growth were to continue to exceed the growth of food production, we could truly be in the grip of a global food crisis.

Resources and Productivity.—Agricultural production, as a biological process, depends on the world's natural resource base, especially soil and water, and favorable climatic conditions. The world's supply of land and water is relatively fixed, although its utility for agricultural production can be modified over time through investment. Most land well adapted for agricultural production is being utilized, and the easily harnessed supplies of irrigation water have been exploited. The proportion

of growth in global agricultural production derived from expansion of cultivated area and irrigation has been declining.

New lands recently brought into production tend to be fragile, their productive life under technologies being used appears quite limited, and in many cases, such as the Amazon of Brazil, their use for agricultural production is thought to have serious negative long-term effects on the world's environment and climate. There is a growing concern that misuse of land and water in agricultural production is degrading the world's land and water resource base in a way that may be irreversible and which, in the long run, will reduce its long-term productive capacity.

As the supply of additional land and irrigation water to be brought under production has diminished, increases in food production have derived increasingly from the application of new technology, much of which has depended heavily on intensive use of chemicals (including fertilizers), which has led to degradation of the environment through pollution of ground and surface water and, in some cases, the atmosphere. There are also increasing concerns about the effect of chemicals on the safety of the food supply.

As agriculture has become increasingly technology-dependent, questions are raised about the ability of science to provide a sufficient future stream of new technology to keep pace with increasing demands for food. Science has not failed to discover new production enhancing methods. A concern about the ability of new technology to produce adequate food supplies well into the future is the adaptability of modern technology in the low-income, food-deficit developing countries of the world. Historically, modern technology has been dependent on a more highly educated farmer and a market and institutional infrastructure to support the inputs in which technology is embodied. In general, the poorer developing countries are poorly prepared in terms of human capital and infrastructure to support adoption of modern technology.

It is clear that the economic activity of mankind is changing the composition of the earth's atmosphere in ways that are causing long-term climatic change. There is some concern about the consequences of global warming. Most analysis to date indicates that this will be a slow process, and probably will not have serious consequences for a number of decades. Analysis also indicates that there will be both positive and negative effects from a rise in global temperature and associated changes in rainfall pattern. Some regions of the world may become less hospitable to agricultural production, but others may become more productive. It is difficult to anticipate the net effect on global productivity. It is clear, however, that global climate change will require change and adaptation if its negative consequences are to be minimized.

Food Policy.—The agriculture and food policy environment is also a cause for concern with respect to the world ability to adjust to changing supply, demand and environmental conditions. Policies which insulate domestic producers and consumers from world market forces restrict the flexibility of the world to adjust to changing supply/demand conditions and can lead to overuse of the natural resource base and the environment. A policy environment that remains distortive provides another reason for concern about the long-term future of the global food supply.

Individual policies can also affect a country's productive capacity. For example, in Africa, our research indicates that one of the major factors behind slow production growth is governments' agricultural and food policies—including inadequate producer incentives. Government policies that favor urban consumers and provide low prices to producers often stifle adoption of productivity enhancing technologies.

ON BALANCE, HOW DOES THE FUTURE LOOK?

Simply enumerating all the phenomena that give observers cause for concern about the longer-term global food situation does indeed point to some dangers ahead. However, our assessment of these "dangers" is that we either have or are developing means to deal with them. Still, the current conditions which give cause for concern have evolved over a longer period of time, and changing these conditions will require time and action.

It is true that the supply of land and water for agricultural production is limited and that the resource base, in many cases, is being degraded by improper use. However, there already exist technologies which, if adopted more broadly, could increase the efficiency of water use greatly. With appropriate technology and practices, much of the land currently being lost through erosion and salinization could be preserved, and additional marginal lands brought into production in an environmentally sound way. While land and water degradation poses serious problems, it does not appear to be a cause for concern about the ability to produce an adequate food supply over

the next two or three decades. Corrective action is necessary, however, if many of the developing countries are to achieve a sustainable agricultural production base.

Another positive factor in the long-term outlook for food production, that is somewhat related to the water resource issue, is aquaculture. The global commercial fish catch has stagnated during the 1990's. ERS analysis indicates that aquaculture has the potential to supplement the stagnating or declining world fish catch. Aquaculture already accounts for approximately 25 percent of worldwide shrimp and salmon production/consumption. As harvesting limits are reached, or are placed on more species, aquaculture holds the technological potential to fill the gap.

Technology breakthroughs are always difficult to predict. However, there is significant stock of technology which has not yet been adopted, especially in the low-income developing countries. Of the 2 percent annual growth in productivity in the developed countries over the past 20 years, which I mentioned earlier, almost all of that growth derived from technological change. Growth is coming from genetic improvements in seed varieties and other technological improvements, not simply from increased use of fertilizer or other chemical inputs. There is no indication that this trend in technological change and improved productivity is diminishing over time—particularly at a time when biotechnological innovations, such as genetic engineering, appear to offer great potential for increasing agricultural productivity. Two serious problems must be dealt with as these areas of science produce technology, if it is to have a positive impact on world food supply. One that is already being confronted is the possible negative effects of these new technologies on the world's environment and the safety of food for human consumption. The other is whether the new technology can be applied to conditions in poor developing countries and therefore help alleviate food shortages where they are most likely to occur.

Almost as difficult to predict as technological breakthroughs are major policy breakthroughs. Nevertheless, I believe there is significant evidence that a major shift in the global policy environment is before us. After decades of increasing levels of protectionism, the agreements reached in the GATT negotiations, particularly on agriculture, tropical products, and intellectual property offer real promise for reducing distortions and resource inefficiency in the marketplace, and for increased movement of goods and technologies among countries. Another positive sign has been the significant reform of policy undertaken unilaterally by many of the developing countries. Such reforms, as applied to the agricultural sectors, should provide market incentives for producers to adopt existing and new technologies. The productivity gap between the developed and the developing countries could begin to narrow.

On balance, it appears that in the next two to three decades the longer-term phenomena that are causing concern do not pose an insurmountable obstacle to the world food system. In this time frame, food crises will likely continue to be localized as a consequence of policy-induced inflexibilities in the global food system and due to a lack of effective demand, rather than of failure of supply. In the longer term, there are threats to the productive capacity of the world. However, there is little doubt that there are means by which such dangers can be avoided, and there is time to implement these actions. It is critical to the well being of future generations that the countries of the world move forward expeditiously to take the necessary actions to ensure the continued ability to provide adequate food supplies at reasonable cost.

Mr. Chairman, that completes my testimony on world food production. I will respond to any questions you or other members may have.

BIOGRAPHICAL SKETCH

B.H. ROBINSON

Dr. Robinson is Director of Agriculture and Trade Analysis Division, Economic Research Service (ERS), U.S. Department of Agriculture. He received a Ph.D. in agricultural economics from Clemson University and a Master Degree from North Carolina State University. He was an Associate Administrator of ERS, a professor, and Head of Agricultural Economics Department at Clemson University. Dr. Robinson is the Leader of the U.S. Delegation to OECD Committee for Agriculture and Executive Director of ERS' Eastern and Central Europe Technical Assistance Program. Dr. Robinson received a USDA Superior Service Award and Presidential Rank Award in 1992.

WORLD POPULATION CAPACITY

Senator BUMPERS. Dr. Knipling, do you have a horseback guess as to how many people we can sustain under present technology in

the world? Do you have a guess on that? That is really more or less for Mr. Brown's field perhaps.

Dr. KNIPLING. I believe the world population now is on the order of 5 billion. I think we have the capacity to feed that number, as well as additional, in terms of the production capacity we have right now, if in fact some of the distribution issues that Mr. Robinson spoke about could be addressed. In terms of equating that to an additional number I just do not know, but I think it would be in excess of the world's population as it is today.

IRRADIATION

Senator BUMPERS. Does irradiation have a role in solving this problem?

Dr. KNIPLING. I think it has many useful potential applications as we deal with food safety and food preservation items. In addition to the distribution problems that have been mentioned, we lose so much of our production in storage and marketing channels due to spoilage. Food that we do produce never reaches the table.

Senator BUMPERS. Last year Dr. Finney testified before this subcommittee that 25 percent of the world's food supply—25 percent of the world's food supply is lost to spoilage or pests. Now, pests are one thing, and spoilage is something else.

The Indian Ambassador was in my office yesterday afternoon and he was talking about the fact that they need 25 megawatts of additional power over the next 20 years. He said you can go down to the food stalls in India, any city in India at 5 or 6 o'clock in the afternoon, and whatever they did not sell just goes under the table to rot, and they do not have any way of storing it or preserving it. And certainly the 25-percent figure would sound high except you have heard all of these graphic stories about Russia and how much of their grain is lost to spoilage and so on, as well as their fresh vegetables.

Dr. KNIPLING. I am not sure of the numbers but I agree with the concept. In terms of pests, even before harvest we probably lose one-third of our production potential or never realize the biological production potential due to pests in the field. And then the pest loss or spoilage loss after harvest is in addition to that.

So if the 25-percent number you cited is correct, I am sure we are losing that much in the field as well. We are talking about 50 percent production enhancement just with what we now have.

SEED BANKS

Senator BUMPERS. If you cut that by 5 percent that would be a significant contribution to the world food stocks. Dr. Knipling, I specifically asked staff to have somebody here to testify about seed banks. I do not know anything about it, but I keep reading about our repositories for all the different seeds.

And what I want to know is how do these seed banks operate, and how many does the Department of Agriculture maintain?

Dr. KNIPLING. I mentioned this briefly in my testimony. The USDA does sponsor a plant genetic resource system which is fairly well developed, and we are just beginning to consider other life forms as well—livestock species and microbial species, aquaculture species, and so forth.

I provided Mr. Kuhn a brochure that describes the U.S. National Plant Genetic Resources System. We have a network of about 20 locations and repositories in the United States geographically dispersed, each specializing in one set of crops or another. Some of these are in the form of seed storage and others are the form of what we call clonal storage where we preserve the material, mostly fruit species, in vegetative fashion.

We have one National Seed Storage Laboratory at Fort Collins. This is the so-called base collection or the backup collection; then we have a network of what we call working collections at various places. At the laboratory locations, field locations where the scientists are actually doing breeding and genetic enhancement work, we have the so-called smaller active collections.

CLONAL REPOSITORIES

Senator BUMPERS. But what I do not understand, what is the basic reason for what you called clonal storage?

Dr. KNIPLING. Certain species, and as I said most of these relate to the fruit species, apples as an example, do not breed true as a seed. Therefore, if we want to preserve the genetic characteristics of a given line we have to maintain that in a vegetative fashion.

Senator BUMPERS. Do they change? For example, do apples change their characteristics if you continue to use the same seed?

Dr. KNIPLING. If you use the same——

Senator BUMPERS. I mean, is there a form of inbreeding here that takes place?

Dr. KNIPLING. The vegetative property will not change genetically. Now, if an apple tree is pollinated with another, that seed will not breed true from the parent. But that is, in fact, a method for expressing the biological genetic diversity from which future selections can be made, but it will not breed true from the parents.

WORLD FOOD DISTRIBUTION

Senator BUMPERS. I would like to see one of these some time. I am going to maybe go to Fort Collins or someplace some time. I would like to see how that thing operates.

Dr. Robinson, you know I enjoyed Mr. Avery's testimony, but I am really troubled by it because, I do not know, there was just something in my opinion that was missing about this problem. I mean I just see it as a multifaceted problem.

One is, some countries do not have very much arable land and their population continues to grow at a rapid rate. Maybe that same country does not have any rainfall. And all those things, for example, coalesce to make an impossible situation for them.

As I said in the opening statement, that is what future wars are going to be fought about—hunger, people looking for food. And immigration is one of the biggest problems this country has right now. You get in a cab in Washington. The guy speaks broken English. What is he doing here? I will tell you what he is doing here. He is trying to feed his family. He could not feed his family in Cameroon or Ethiopia and so he comes here.

It is already a big demographic problem, ethnic problem, religious problem. Those people, let us face it, come here and bring alien philosophies, religions that are sort of unknown to us, some

of them even carry a militaristic sort of religion, and it is creating a terrible problem for us.

But it seems to me that Mr. Avery's discussion of this just says, well, if we had jobs for all those people where they live this would not be happening. It makes me think of a dirty story I cannot repeat here but, you know, if a lot of things happened the world would be a much better place to live.

What do you do about a country like Somalia, with 6½ million people that could probably not sustain in any degree a decent lifestyle for more than 2 to 3 million people, and the birth rate there continues at about the pace it always has?

Dr. ROBINSON. Let me try to respond to that in two ways, Senator. I think you have an excellent point. First, getting back to one of the points that I made, if we look at food production and food supply potential globally, in the aggregate, I think that potential is there for the population, particularly with the stream of technology no greater than the one that we have already experienced.

The problem, as you point out, is a localized problem, and some of those localized problems are year-to-year variations caused either by a drought or by civil strife in a country and so forth.

There is, however, that other group of countries where the population growth is in excess of the production capacity of that country on a longer term basis. And the question arises, is that a sustainable operation? To me there are four answers for it.

One, they can increase the production of agricultural products, and there is some potential, Senator, for that in terms of some of the technology that is yet to be adopted in those countries and some of the education that could occur. The second one is that they must constrain, to some extent, the population growth that they are experiencing, as you have pointed out.

The third is to have sufficient income to generate food from commercial purchases on the international market from those countries that have excesses.

And a fourth one, which is the one that has been pursued and, quite frankly, I see it as being one of the issues that is going to continue somewhat in the future, is food aid. Food aid is simply going to be required in many of those countries in order to continue to be able to provide minimum food for them.

I do not see in those localized areas production increasing rapidly enough. I do not see population being controlled rapidly enough. So, it defines for us a chronic problem, and I think that is the problem you were pointing to a bit earlier.

SUBMITTED QUESTIONS

Senator BUMPERS. I have got three or four questions that I will submit in writing. We are running much longer today than I thought we were going to.

I want to thank you for being with us this afternoon. I wanted the Department of Agriculture or ERS to have some input into this hearing, and this will not be the last hearing we have on this subject.

It is an area that I consider vitally important to the world and to the United States, and we are just going to have to keep talking

about it until people focus more dramatically on it than they have in the past.

I thank you both very much for being with us this afternoon.

Dr. ROBINSON. Thank you, Mr. Chairman.

Dr. KNIPLING. Thank you.

[The following questions were not asked at the hearing, but were submitted to the Department for response subsequent to the hearing:]

QUESTIONS SUBMITTED BY SENATOR BUMPERS

SEED BANKS

Senator BUMPERS. Where are the seed repositories in the United States?

Dr. KNIPLING. The Agricultural Research Service operates a number of repositories itself and others with State Agricultural Experiment Station partners as part of the National Plant Germplasm System (NPGS). The NPGS manages seed as well as vegetatively or clonally propagated crops such as the tree and nut crops. The clonally propagated crops are normally kept in orchards rather than seed banks since their seeds would not reproduce true to type. They are propagated by taking cuttings which are grafted to root stocks. Tissue culture and artificial media are available to backup some, but a long way from all, of these plants in the laboratory. Research has developed techniques for storing some of these, such as apple buds, in liquid nitrogen.

Continuing research will hopefully enable more of these crops to have the safety backup in the laboratory just as the seed crops can be stored in a seed bank. The primary germplasm repositories and the crops they maintain are:

Davis, CA—almond, fig, grape, kiwi, mulberry, olive, persimmon, pistachio, pomegranate, stone fruit, and walnut

Riverside, CA—citrus and related genera, and dates

Salinas, CA—lettuce genetic stocks

Fort Collins, CO—base seed collection of major economic crops

Washington, DC—numerous woody landscape genera

Miami, FL—annona, avocado, mango, passiflora, sugarcane

Griffin, GA—cowpea, melon, peanut, pepper, sorghum, and sweetpotato

Tifton, GA—pearl millet

Hilo, HI—acerola cherry, atemoya, breadfruit, carambola, guava, litchi, macadamia, papaya, passion-fruit, peach palm, pili nut, pineapple, and rambutan

Ames, IA—alfalfa, cabbage, maize, melon, sugarbeet, sunflower, and soybean genetic stocks

Aberdeen, ID—barley, oat, rice, rye, triticale, and wheat

Urbana, IL—maize genetic stocks and soybeans

Columbia, MO—triticale and wheat genetic stocks

Oxford, NC—tobacco

Fargo, ND—durum wheat genetic stocks and flax

Geneva, NY—apple, brassicas, celery, clover, hardy grape, squash, and tomato

Corvallis, OR—blackberry, blueberry, cranberry, current, filbert, gooseberry, hop, mint, pear, raspberry, and strawberry

Mayaguez, PR—banana, Brazil nut, cacao, coffee, mango, and plantain

Brownwood, TX—chestnut, hickory, and pecan

College Station, TX—cotton and cotton genetic stocks, and sorghum genetic stocks

Logan, UT—range grass collection

Pullman, WA—alfalfa, bean, chickpea, grasses, lentil, onion, pea, and safflower

SEED BANK OPERATIONS

Senator BUMPERS. How do they operate?

Dr. KNIPLING. The repositories, which receive germplasm from many sources, both domestic and foreign, are connected electronically through the Germplasm Resources Information Network (GRIN). GRIN is a database and management tool by which new plant collections are registered and entered into the system by assigning a specific "PI" number, entering passport data, and subsequent characterization and evaluation data obtained through growouts and testing. The repositories normally receive the new collections from the plant introduction office or quarantine center and they grow it out to increase seed quantities. A fraction of the seeds are sent to the National Seed Storage Laboratory at Fort Collins, Colorado for the base collection.

The remaining seeds are retained at the repository for distribution to scientists who wish to utilize them for their research. The requests and the distributions are managed through an order processing system in GRIN.

GROWOUT OF SEEDSTOCKS

Senator BUMPERS. How often do you grow out the seeds to replace/refresh them?

Dr. KNIPLING. The frequency and size of growouts depend upon quality and/or quantity of seeds in storage. Oftentimes, seeds must be regrown to replenish the supply available for distribution due to high demand. Other times, particularly with sensitive seeds, they must be regrown because of quality deterioration. With the excellent seed storage conditions which exist in the newly expanded National Seed Storage Laboratory, most seeds stored in the base collection will last for extended periods without regeneration. Growouts are usually required frequently after a new collection has entered the system due to demand but quite infrequently after scientists have exploited it for known attributes.

INTERNATIONAL SEED BANKS

Senator BUMPERS. Where are other major seed banks around the world? How do we cooperate with them?

Dr. KNIPLING. Besides the extensive germplasm collections in the U.S., several countries maintain large collections and diverse major collections. These include Brazil, Canada, China, Colombia, Ethiopia, India, Mexico, Peru, and Russia. Large, crop-specific collections are held at international agricultural research centers of the Consultative Group on International Agricultural Research (CGIAR) in developing countries. Some examples of important crop-specific collections are:

Crop	Location	Organization
Bean	Cali, Colombia	International Center for Tropical Agriculture.
Chickpea	Hyderabad, India	International Crops Research Institute for the Semi-Arid Tropics.
Cowpea	Ibadan, Nigeria	International Institute for Tropical Agriculture.
Maize	El Batan, Mexico	International Center for Maize and Wheat Improvement.
Peanut	Hyderabad, India	International Crops Research Institute for the Semi-Arid Tropics.
Pearl Millet	Hyderabad, India	International Crops Research Institute for the Semi-Arid Tropics.
Pidgeonpea	Hyderabad, India	International Crops Research Institute for the Semi-Arid Tropics.
Potato	Lima, Peru	International Potato Center.
Rice	Los Banos, Philippines	International Rice Research Institute.
Sorghum	Hyderabad, India	International Crops Research Institute for the Semi-Arid Tropics.
Wheat	El Batan, Mexico	International Center for Maize and Wheat Improvement.

The USDA cooperates with these gene banks through exchanges of germplasm, information and technology. The United States has a policy of providing germplasm freely to research scientists. It thus exchanges germplasm with scientists and institutions worldwide. In 1993, over 30 percent of the distributions from the NPGS went to foreign destinations. Scientists in the U.S. often request and receive germplasm from other country programs and from international agricultural research centers for their research programs. In addition, there is considerable collaboration in the global germplasm and commodity breeding communities for sharing information and germplasm.

PERCENTAGE OF GERMPLASM IN SEED BANKS

Senator BUMPERS. What percentage of the germplasm that exists in the United States today is maintained in our seed banks? What is the corresponding figure for germplasm in the entire world?

Dr. KNIPLING. A high but undetermined percentage of unique U.S. germplasm is maintained in U.S. seed banks. The NPGS maintains basic and essential germplasm in the U.S. base collection at Fort Collins, Colorado. Other repositories maintain the

active collections of germplasm available for distribution to scientists. The scientists maintain working collections of germplasm they have acquired to support and be convenient in their breeding programs. Only unique new cultivars and germplasm from those programs are in the seed repositories. In addition, seed saver organizations maintain many old and unique cultivars of historical interest. The NPGS seeks new germplasm internationally to fill gaps in its collections for genetic diversity for research on the many crop species grown in the United States.

In the entire world, many farmer varieties of crops are maintained by the peasant farmers in developing countries. While many of these have been collected and placed in seed banks, ownership of germplasm issues have slowed the access to those varieties by international organizations. The percentages in seed banks will vary by commodity but there remains much collecting to be done on some major and on many minor crops at the same time that international politics has slowed the access.

FOOD AID

Senator BUMPERS. Dr. Robinson, you indicate that the developing countries who are in a food deficit situation would require 14 million tons of food aid in 1993/94 to maintain per capita grain consumption at the average of the last five years. How much food aid is currently provided to those countries?

Dr. ROBINSON. We estimate that 10.2 million tons of food aid is currently provided to the 60 developing countries covered by the Food Aid Needs Assessment.

Senator BUMPERS. How much is provided by the United States?

Dr. ROBINSON. The United States provides about 55 percent of world food aid including 5.6 million tons to these 60 countries.

NONDEPARTMENTAL WITNESS

THE HEALING FOREST CONSERVANCY

STATEMENT OF KATY MORAN, EXECUTIVE DIRECTOR

INTRODUCTION OF WITNESS

Senator BUMPERS. Our last witness is Katy Moran, executive director of The Healing Forest Conservancy. She is substituting for Kenny Ausubel, the CEO of Seeds of Change. We welcome you, Ms. Moran, to our committee and look forward to hearing from you.

Ms. MORAN. Thank you, Mr. Chairman. I personally would like to thank you for calling this hearing. I think you are touching on a topic that must be addressed immediately. And I would suggest, as Mr. Brown said, that you look at the article on the cover of the Atlantic Monthly, and you may want to decide to put that in the record of this hearing.

I am here because Kenny Ausubel got snowed in in Chicago. And I am not an expert on agriculture, sir, but I would like to perhaps at the end of this statement that he submitted respond to some of the, I think, gross misconceptions that Mr. Avery, who accused Lester Brown of misconceptions, gave in his statement, and I do have some thoughts on that.

I address you today for Kenny Ausubel, founder and CEO of Seeds of Change, an organic seed company for backyard gardeners like myself. Kenny is also the author of the newly released book, "Seeds of Change: The Living Treasure" which provides substantial documentation of the threat posed to the world's food supply by the loss of biodiversity.

The book also documents the grave health and environmental risks we face as a consequence of the dependence of our agricultural systems on synthetic petrochemicals.

The "Seeds of Change" book has generated a PBS national investigative documentary entitled "The Genetic Time Bomb," about the global peril posed by the loss of diversity in our food system. The film will air later this year and features Seeds of Change, Vice President Gore, and others.

Food plants are not natural. Rather, they are the sophisticated products of hundreds and thousands of years of brilliant gardeners and farmers cultivating and selecting them for favorable characteristics that accommodate to diverse local growing conditions.

However, their displacement by the first generation hybrid seeds, and I think this responds to a question you asked earlier, that are excessively favored by large companies in the latter 20th century has created an avalanche of extinctions of this biological diversity. The companies favor these hybrids which adapt to large factory farming whose highest value is uniformity rather than diversity.

Yet the conservation of biological resources and biodiversity has been increasingly recognized as fundamental to economic stability and competitiveness in world markets.

Extinctions today, however, are running at 1,000 times the natural rate, or to 27,000 species a year. While great attention is paid to the loss of diversity by the destruction of natural habitats like rain forests the loss of biodiversity in our food systems has been a gravely underrecognized problem. As much diversity is lost in farmers' fields as in the wild, according to the recent National Academy of Sciences report by the National Research Council, as well as the 1993 report by the Food and Agricultural Organization of the United Nations.

These studies underscore the severe situation in U.S. agriculture whereby reliance on a very few kinds and varieties of crops opens the farm gate wide to potential disaster on an almost unimaginable scale. Nature favors diversity, yet U.S. agriculture today is based on fewer and fewer kinds and varieties of seeds, many of them closely genetically related.

Today, 97 percent of the kinds of foods available to our grandparents only 100 years or so ago are gone. In Europe, three-quarters of traditional seed varieties are literally on the edge of extinction. Currently we rely on only about 20 plants for 90 percent of our food, and very few varieties of each of these crops make up the huge majority of production.

Where there were 30,000 kinds of rice routinely grown until 20 years ago, only about 10 account for most of the rice grown today. Similar statistics obtain for virtually every major crop, so the potential for catastrophe in food production on a huge scale is real and immediate.

The practical value of diversity lies in its variety of biological options to counter a pest, disease, or any of the myriad changes in nature. Without diversity we limit our options to adapt to change.

Recently, scientific studies clearly showed the ecosystems with too few species lacked the resilience to adapt to drought or other crises, where as those environments with diverse species rebound quickly.

Seeds of Change is a biodiversity company and our seeds are available and valuable for their ability to adapt. At the core of the operation are several impassioned seed collectors who, at the same time they witnessed the catastrophic loss of diversity around them, simply took individual action to counteract the loss of diversity.

They began to collect all the seeds they could get their hands on and planted them safely in their own backyards. They gathered many heirloom and traditional varieties of the living treasure of food plants passed through countless generations of farmers.

What Seeds of Change has done is to grow out these seed stocks into commercial quantities and market them to backyard gardeners. Because gardening is the largest leisure time activity in the United States, Seeds of Change has demonstrated that backyard gardeners can act as a mechanism for conserving biodiversity by planting a green necklace of living gardens across the land. Our strategy is to commercialize backyard biodiversity into as many hands and lands as possible.

These seeds of change, many of which were virtually on the edge of extinction only a few years ago, are now held by tens of thousands of gardeners available through the company's mail-order catalog and through well over 1,000 retail outlets.

Seeds of Change is employing an economic strategy and a partnership with the very large market of backyard gardeners as a volunteer army in service of biodiversity. It is a business strategy consistent with environmental restoration.

Likewise, Seeds of Change has made an unequivocal commitment to sustainable organic agriculture. We are the only company producing exclusively organic seeds, the first link in a safe food chain.

The National Academy of Sciences 1989 alternative agriculture report strongly recommended a national policy shift to sustainable organic farming, yet there have been scant Federal actions or funding to advance this crucial transition.

Consequently, agriculture today is the largest single nonpoint source polluter of any industry in the United States. It takes nature thousands of years to create topsoil, yet the overuse of the petrochemical cycle of synthetic fertilizers and toxic pesticides and fungicides is causing the loss of an inch of topsoil a year.

PREPARED STATEMENT

Senator BUMPERS. Ms. Moran, let me interrupt you at that point, because I am going to have to shut this hearing down because of another rather urgent thing I have to attend. We have Mr. Ausubel's complete statement and it will be made part of the record along with the biographical sketches.

[The statement and biographical sketches follow:]

STATEMENT OF KENNY AUSUBEL, FOUNDER AND CEO, SEEDS OF CHANGE, INC.

INTRODUCTION

I address you today as the founder and CEO of Seeds of Change, the nation's preeminent organic seed company for backyard gardeners, and also as the author of the newly released book, "Seeds of Change: The Living Treasure." The book, which I submit for your review along with this statement, provides substantial documentation on the issue of the threat posed to the world food supply by the loss of biodiversity. The book also documents the grave health and environmental risks we face as a consequence of the dependence of our agricultural systems on synthetic petrochemicals, to whose narrow needs all our hybrid seed stocks have been adapted. The book further examines the resulting reduction in nutritional content in our foods. The Seeds of Change book has generated a PBS national investigative documentary, entitled "The Genetic Time Bomb" about the global peril posed by the loss of diversity in our food system. The film will air later this year, and features Seeds of Change, Vice-President Gore and others.

According to James Gustave Speth of the United Nations Development Program, "If the world's people are to have a nutritionally adequate diet, world food output must at least triple over the next half century * * *. The goal of achieving sustainable food security in the decades ahead emerges as one of the greatest challenges humanity has ever faced."[1] And, as Vice-President Gore has stated, "The single most serious strategic threat to our food supply is genetic erosion."[2]

Seeds of Change is working through the private sector to help solve these problems and arrive at a sustainable and diverse agricultural policy for the 21st century. We wish to raise several questions and proposals in relation to enhancing world food production. I humbly offer this committee our experience as a model which may pro-

[1] "Towards Sustainable Food Security," James Gustave Speth, Consultive group on International Agricultural Research, Washington, DC, 10.25.93.

[2] Earth in the Balance, Al Gore, Houghton Mifflin, 1992, p. 144.

vide useful information. We recognize that we are just one model, and a modest one at that.

BIODIVERSITY AND WORLD FOOD PRODUCTION

Two years ago, Seeds of Change received a letter in the mail along with a couple of bean seeds. They were sent to us by a Preacher James Couch in North Carolina. One of his elderly parishioners died, and in going through her meager possessions with her family, they found a small box of bean seeds. They were very beautiful, like painted jewelry, and the Preacher asked about them. The family said that she had been an avid gardener, and these were the family heirloom beans, brought over from Europe by their great grandmother. The family had no interest in them, and Preacher Couch contacted Seeds of Change with his new mission. In the last two years, he has sent us over a hundred kinds of corn and beans collected from old-timers all over the Appalachian mountains. Without his personal effort, this living legacy of seeds would almost certainly have been lost forever.

We must remember that these food plants are not "natural"—rather they are the sophisticated products of hundreds and thousands of years of brilliant gardeners and farmers cultivating and selecting them. These food plants are entirely reliant on people to cultivate them to survive. Their displacement by the first-generation hybrid seeds excessively favored by large companies in the latter 20th century has become an avalanche of extinctions. The companies favor these hybrids for purely commercial reasons including their proprietary nature and a set of industrial specifications adapted to large factory farming whose highest value is uniformity.

The conservation of biological resources and biodiversity has been increasingly recognized as fundamental to economic stability and competitiveness in world markets. Biodiversity is the invisible underpinning for much of the world economy. Yet extinctions today are running at 1,000 times the natural rate, 27,000 a year. While more attention is being paid to the loss of diversity by the destruction of natural habitats, the loss of biodiversity in our food system has been a gravely under-recognized problem.

As much diversity is being lost in farmers' fields as in the wild. The recent National Academy of Sciences report by the National Research Council, as well as the 1993 report by the Food and Agricultural Organization of the United Nations, again underscore the severe situation in U.S. agriculture whereby reliance on a very few kinds and varieties of crops opens the farm gate wide to potential disaster on an almost unimaginable scale. Nature does not favor centralization, yet our entire agriculture today is based on fewer and fewer kinds and varieties of seeds, many of them closely genetically related. The prospect of biotechnology only increases this dangerous centralization and uniformity. The NAS has identified uniformity as "the enemy."

Since only a hundred years ago, of the kinds of foods available to our grandparents, an estimated 97 percent are gone. In Europe, three quarters of traditional seed varieties are literally on the edge of extinction. Today, we rely on only about 20 plants for 90 percent of our food; a mere 9 kinds of plants account for 75 percent; only three account for 50 percent. Very few varieties of each of these crops make up the huge majority of production. Where there were 30,000 kinds of rice routinely grown till only 20 years ago, only about 10 account for 75 percent today. Similar statistics obtain for virtually every major crop today.

Because of genetic engineering, many of these few kinds contain literally identical genes, and are bred from closely related elite species lines. The potential for catastrophe on a huge scale is real and immediate. In fact, it occurred in 1970 with the Southern Leaf Corn Blight where the nation lost 50 percent of our corn from Florida to Texas. A biologist compared the situation to one in which a burglar breaks into an apartment building, to find that every apartment has the same key.

Farming is a continual game of "crops and robbers". The practical value of diversity lies in its variety of biological options to counter a pest, disease or any of the myriad curveballs of nature. The only constant in nature is change. Without diversity, we cannot adapt to change. These "seeds of change" are valuable precisely for their ability to adapt. Recent scientific studies clearly show that ecosystems with too few species lack the resilience to adapt to drought or other crises, whereas those environments with enough diversity rebound quickly.[3]

Our agricultural over-reliance on F1 hybrid seeds, conditioned to grow with petrochemicals, is directly responsible for much of the loss of diversity in agriculture.

Seeds of Change is a biodiversity company. At the core of the operation are several impassioned seed collectors who, at the same time they witnessed the cata-

[3] "Study Bolsters Value of Species Diversity," New York Times, 2.1.94.

strophic loss of diversity around them, simply took individual action. They began to collect all the seeds they could get their hands on, and plant them safely in their own backyards. They gathered many heirloom and traditional varieties of the "living treasure" of food plants passed through countless generations of human survivors.

What Seeds of Change has done is to grow out these seed stocks into commercial quantities and market them to backyard gardeners. Because gardening is the largest leisure-time activity in the United States, Seeds of Change has demonstrated that backyard gardeners can act as a mechanism for conserving biodiversity by planting a green necklace of living gardens across the land. Our strategy is to commercialize "backyard biodiversity" into as many hands and lands as possible.

Seeds of Change seeds, many of which were virtually on the edge of extinction only a few years ago like those of Preacher Couch, are now held by tens of thousands of gardeners, available through the company's mail-order catalog, and through well over one thousand retail outlets.

Seeds of Change is employing an economic strategy in a "partnership" with the very large market of backyard gardeners as a "volunteer army" in service of biodiversity. It is a business strategy consistent with environmental restoration.

THE TRANSITION TO SUSTAINABLE AGRICULTURE

Seeds of Change has made an unequivocal commitment to sustainable organic agriculture. We are the only company producing exclusively organic seeds, "the first link in a safe food chain."

The National Academy of Sciences 1989 "Alternative Agriculture" report strongly recommended a national policy shift to sustainable organic farming. Yet there have been no significant federal actions to advance this crucial transition.

Agriculture today is the largest single nonpoint source polluter of any industry in the United States. It takes nature thousands of years to create topsoil, which is our "capital". Yet the use of the petrochemical cycle of synthetic fertilizers and toxic pesticides and fungicides is causing the loss of an inch of topsoil a year, an area the size of Connecticut. These chemicals are also polluting water supplies at a time when clean drinking water is being predicted to be "the oil of the 1990s", a precious commodity capable of causing wars. The grim statistics on the effects of agriculturally caused water pollution for both the environment and the public health are going to create expensive, potentially violent strife for the rest of the decade.

Moreover, our entire agricultural system has designed seeds to conform to the use of these chemicals, radically diminishing diversity. In the last 20 years, over a thousand independent seed houses have been acquired by large chemical and pharmaceutical companies which manufacture these agrichemicals, today a $17 billion a year business. It is cheaper to adapt seed stocks to existing chemicals than to invent new chemicals for seeds. Vice President Gore, who corroborates this fact, proposes in his book "Earth in the Balance" that federal legislation be enacted to prevent the so-called "vertical integration" of the seed and chemical industries because of such conflicts of interest.

The sale of organic products has been entirely consumer-driven, doubling in the 1980's and projected to at least double in the 1990's. The market success of Seeds of Change with organic seeds is further evidence of the public desire for such products.

It is important to note that the government of Denmark has created a transitional program to give farmers a fiscal safety net and incentive to transition to organic methods. Where is the political will to assist this critical transition in American agriculture?

FOOD, NUTRITION AND PUBLIC HEALTH

The office of the Surgeon General previously characterized 68 percent of disease as diet-related. As Robert Rodale said, "Farmers are the health-care practitioners of tomorrow." Diversifying our diet and raising organic foods will make a substantial and immediate impact on improving the national health and reducing health-care costs.

Seeds of Change calls its program "nutrition per acre". The company selects seed stocks for their nutritional values, and employs organic growing practices, as documented in our book, to provide superior nutritional content.

WORLD FOOD PRODUCTION AND GLOBAL STABILITY

Once the environmental and health costs of petrochemical agriculture are factored into the economic equation, our current system of food production will no longer provide cheap food. To the contrary, it is being revealed as an unsustainable and costly system. The National Academy study found organic farming to be equally productive

as chemical methods, more profitable, and far superior in its effect on the environment.

World peace will not occur without food security. Yet today our food system is under dire threat from a closely linked formula of a narrow band of hybrid seed stocks conditioned to grow within the strict tolerances of petrochemical agriculture.

Unfortunately the root of the demise of most major civilizations has been ecological imbalance. Central to this imbalance has been people's inability to learn to feed ourselves through sustainable farming methods. We face a critical juncture today to begin practicing a sustainable agriculture founded on the biology of diversity. If we can solve this riddle, we will have succeeded in building the bridge to the next millennium.

THE ROLE OF BUSINESS IN SUSTAINABLE DEVELOPMENT

Seeds of Change is operating through the private sector to restore diversity into our agriculture and food system, while helping demonstrate the viability of sustainable agricultural practices. Yet what the company has achieved has taken place without public assistance, grants, subsidies or supports of any sort. We have been supported by a group of visionary investors at substantial personal risk. It has been an extremely difficult enterprise, fraught with all the obstacles of any small business.

Seeds of Change today provides 50 full-time jobs, as well as the principal source of income for an additional 80 organic seed growers across the land. These growers are all small family farmers who might otherwise perish. In the foreseeable future, the company will support double or triple this many employees and farmers.

We ask why there are no incentives for investors to support companies such as ours which are actively trying to address major environmental and social issues, companies driven by environmental and social values as well as by financial profit.

Clearly, business and the environment are very compatible in the case of Seeds of Change. We believe that business must act as a primary vehicle for solving environmental problems such as the loss of biodiversity. We also believe that business can lead the way in demonstrating models of sustainable development. We are demonstrating that large segments of the public can be mobilized through the market as Seeds of Change is doing with gardeners to address the magnitude of the environmental crisis.

RESTORING THE WEB OF LIFE

Biology shows us that when only one plant becomes extinct, along with it disappear the twenty to forty animal and insect species which rely on it. Nature is a tapestry, and diversity is its heart. By removing threads from the fabric, we are unraveling the very fabric of life. Human beings can no longer consider themselves separate from the rest of life. Nature is not a "kingdom", but rather a kin-dom of interdependent relationships. We must learn to honor the kinship of all life in its magnificent diversity.

We hope that the model of Seeds of Change will offer this committee some insight into the essential transition that must take place if we are to enjoy a future environment of health and peace, based on sustainable organic practices and an agriculture of diversity on our family farms and in our society.

BIOGRAPHICAL SKETCHES

KENNY AUSUBEL

Mr. Ausubel is an award-winning filmmaker, writer and environmental entrepreneur whose work has focused on health and the environment.

Mr. Ausubel co-founded Seeds of Change in 1988 after filming the remarkable garden of seedsman and master organic gardener Gabriel Howearth at San Juan Pueblo in New Mexico. The first national company to produce and distribute organic seeds, Seeds of Change is reintroducing a biological diversity of crops into the food chain. (The erosion of the gene pool is widely considered as a primary environmental threat.) Seeds of Change seeds are now distributed through over a thousand retail outlets in the United States and Canada, as well as through the Seeds of Change mail-order catalog.

Harper San Francisco is publishing Seeds of Change: "The Living Treasure," authored by Mr. Ausubel, as Harper's 1994 "flagship book." The company is also prominently featured in "Genetic Time Bomb," a PBS national documentary scheduled for broadcast in April, 1994.

The annual Seeds of Change "Bioneers" Conference, which Mr. Ausubel founded and produces, was named a "Top Environmental Story of 1990" by the Environment News Service. "The Bioneers: Practical Solutions for Restoring the Environment," is the subject of a second Harper book by Mr. Ausubel.

Mr. Ausubel has produced, written and directed three nonfiction films on alternative medicine. The feature documentary film "Hoxsey: How Healing Becomes A Crime," was chosen one of the "Top 25 Censored Stories of 1990," the first film ever selected for the prestigious journalistic award. A dramatic investigation of the American Medical Association's controversial battle against a popular herbal cancer remedy, Hoxsey played in theaters to exceptional critical acclaim, and aired on national cable TV on HBO/Cinemax where its viewer response exceeded that of any other documentary shown to that time. The film had the rare honor of a special screening for members of Congress at the Kennedy Center. The film's research was requested for donation to the National Library of Medicine.

Mr. Ausubel also produced the documentaries "Hope and a Prayer," with Dr. Bernie Siegel, author of the best-selling book "Love, Medicine and Miracles," and "Los Remedios: The Healing Herbs," which aired on regional PBS.

Mr. Ausubel grew up in New York City, where his father taught at Columbia University. After attending Yale, he gained his B.A. from Columbia in Psychology, graduating Phi Beta Kappa in 1972.

KATY MORAN

Katy Moran, formerly with the Smithsonian Institution, is a biological anthropologist. Moran is currently Director of the Healing Forest Conservancy, a nonprofit environmental organization committed to the conservation of biological diversity. She works with progressive businesses, primarily the pharmaceutical industry, to promote awareness of the importance of conservation of biological diversity for commercial enterprises, and now is focused on U.S. ratification of the Convention on Biological Diversity.

ACCOMMODATING CHEMICALS TO SEEDS

Senator BUMPERS. First of all, I have read this statement and you have just reached the point that really captured my attention in this whole statement, and I wanted you to explain to me if you can. How is the use of petrochemical cycles, synthetic fertilizers, and toxic pesticides and fungicides—how is that causing the loss of an inch of topsoil a year? How does that happen?

Ms. MORAN. Well, Mr. Ausubel can give you the data on that. I am reading his statement on this.

I think that his book "Seeds of Change" documents that very process in that a lot of this topsoil cannot be used anymore. It is so polluted that it, I believe, cannot accommodate the growth that it should be able to.

Senator BUMPERS. Well, perhaps I should submit three or four questions because I am concerned also about a statement in there regarding accommodating chemicals to the seeds that exist rather than trying to accommodate the seeds to the chemicals. Is that a fair statement? Did I say that right?

Ms. MORAN. Yes; according to Mr. Ausubel's statement the seed companies have accommodated their new seeds to the chemicals that exist rather than to work on the creation or technology to have new kinds of seeds.

Senator BUMPERS. Here is the statement, and I will send you a written question so you can answer it perhaps in a little more detail. "It is cheaper to adapt seed stocks to existing chemicals than to invent new chemicals for seeds." And you point out that Vice President Gore touched on that in his book, "Earth in the Balance." I do not understand that and a couple of other things here.

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Well if I may, and in the interest of time, let me submit those in writing.

Let me ask you one other question. How old is this organization, do you know?

Ms. MORAN. Seeds of Change began in 1989.

Senator BUMPERS. 1989?

Ms. MORAN. Yes.

Senator BUMPERS. Let me just ask you one question for your answer. Why is a seed that is 100 years old more important than one that is 10 years old, or maybe I misunderstood your statement here?

Ms. MORAN. I would say that what Mr. Ausubel was talking about here is that there are varieties of plants that were used by our grandparents, of over 100 years ago, many of us, that are not available today just because people have stopped growing them because they only use monoculture, just one type of agriculture, rather than a variety of seeds.

And I know on your trip to the Amazon you were with my ex-boss from the Smithsonian Institution, Tom Lovejoy, who I am sure talked to you every night in your hammock about biodiversity, and I think that is where the answer to this question would come in. We are losing biodiversity in the plant world across the board, and agriculture is part of that.

Senator BUMPERS. Ms. Moran, I thank you very much for very ably filling in for your friend today, and we will submit the questions to him. Do you know what kind of a budget this organization—you never did tell me where they are located.

Ms. MORAN. They are located in Santa Fe.

Senator BUMPERS. And what kind of a budget do they have? How big of an organization is it?

Ms. MORAN. They employ 50 people. It is a small organization, but they grow their own seeds to enhance biological diversity, and then the seeds are mailed through a catalog to thousands of backyard gardeners here in the United States and in other countries. So in that way they are maintaining backyard biodiversity, as Mr. Ausubel puts it.

Senator BUMPERS. I married a green-thumber, and occasionally we get seeds in the mail, two seeds, and sometimes we get four or five rather rare species of trees. She religiously puts all of them out. Some of them survive and some of them do not, but it is always fascinating to engage in that sort of thing, and I am glad that there are organizations like yours and there are some others who do the same thing.

SUBMITTED QUESTIONS

But in any event, I thank you very much. We will submit the additional questions to Mr. Ausubel in writing to be answered for the record.

[The following questions were not asked at the hearing, but were submitted for response subsequent to the hearing:]

Questions Submitted By Senator Bumpers

CHEMICAL DEPENDENCY

Question. Mr. Ausubel, you indicate that most commercial seeds available today are adapted to the use of petrochemicals for fertilizer and toxic pesticides and fungicides. How are seeds changed to adapt to these chemicals?

Answer. Seeds are selected out for resistance to certain of the herbicides such as Roundup with an eye toward developing a crop which is glyphosate resistant, for example (glyphosate being the active ingredient in Roundup). The effects of becoming glyphosate resistant are that one can grow specimens using increasing amounts of the herbicide which will kill off the weeds and leave the resistant crops untouched.

Resistance to herbicides, similar to resistance to antibiotics, generates its own set of problems. We don't know what is going to happen with this anymore than we knew what would happen when we generated penicillin resistant strains of bacteria. We do know the ability to apply ever increasing amounts of toxic chemicals insures the on-going eradication of microbes in the soil. The ability to use higher concentrations of the herbicides mean we are poisoning a whole level of soil life that is never talked about.

Question. Does this mean that a gardener could not use these fertilizers, pesticides and fungicides on plants grown from your seeds?

Answer. No.

Question. Would the commercial seeds you condemn not produce as well with organic fertilizers, pesticides and fungicides as with the chemical treatments?

Answer. This really isn't known and it would be worth funding research to find out.

BIODIVERSITY

Question. It is alleged that we currently have 27,000 extinctions a year, or 75 a day, or three an hour. Is this just plant organisms, or animals as well?

Answer. Everything.

Question. How many new plants are being formed each year?

Answer. Virtually none. In geological time, species take thousands, tens of thousands and tens of millions of years to produce. Hybrids are routinely made of known species and there will continue to be large increases in the number of human-made hybrids while the number of wild species decreases.

CONCLUSION OF HEARING

Senator Bumpers. We will conclude our hearing with this. In our next hearing we hear from Secretary Espy on the Department's fiscal year 1995 budget, and that will be Friday, March 4, at 10 a.m. in this room.

The subcommittee will recess and reconvene at the call of the Chair. Thank you all.

[Whereupon, at 4:30 p.m., Wednesday, February 23, the hearing was concluded and the subcommittee was recessed, to reconvene subject to the call of the Chair.]

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